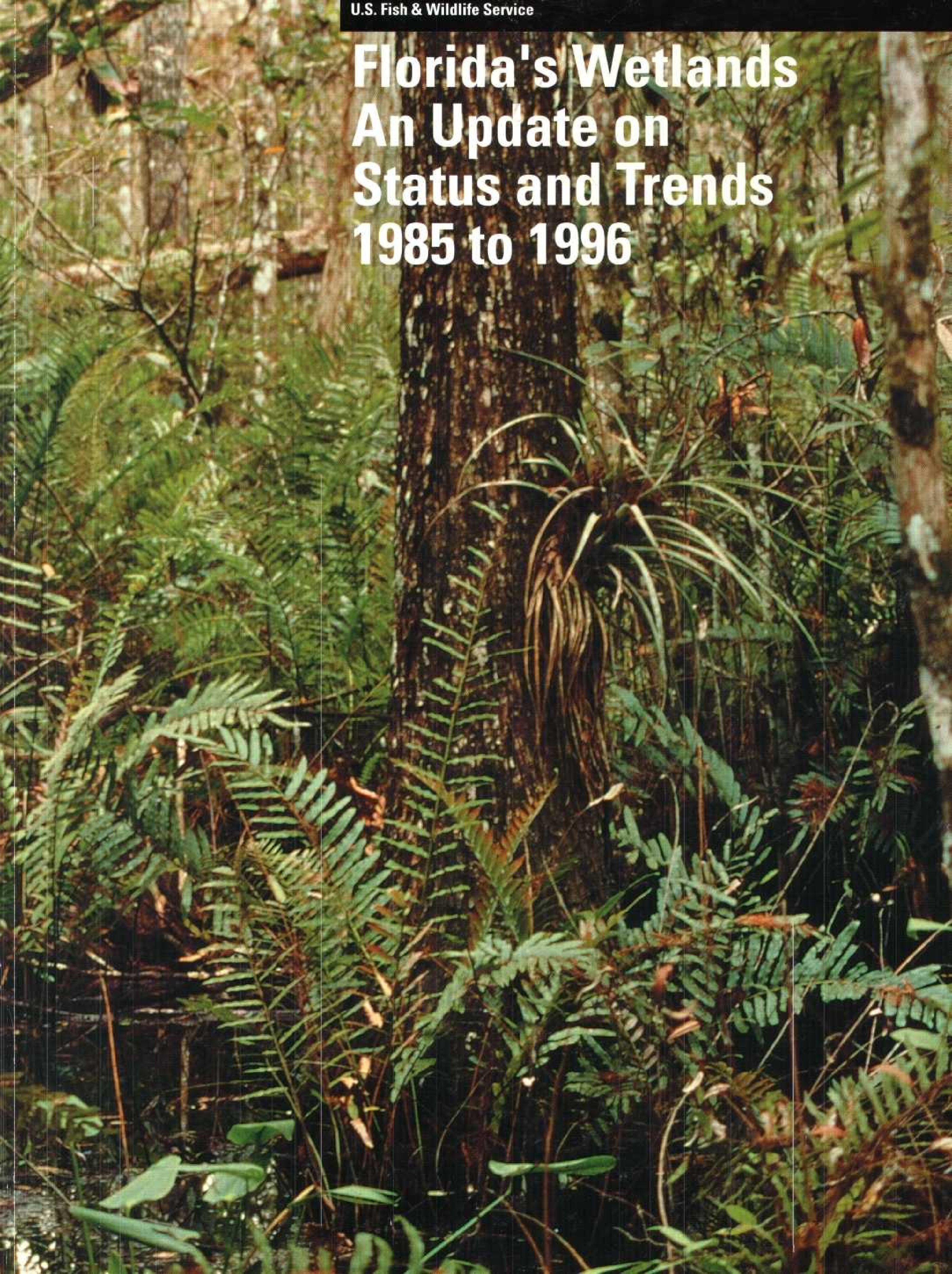
U.S. Fish & Wildlife Service

Florida's Wetlands An Update on Status and Trends 1985 to 1996



Florida's Wetlands

An Update on Status and Trends, 1985 to 1996

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Acknowledgments

Many people within the U.S. Fish and Wildlife Service have provided technical, administrative or editorial support for this project. The author would like to thank the following individuals: Dr. Mamie Parker, Ms. Kathleen Short and Mr. William Knapp, Mr. Everett Wilson, Fisheries and Habitat Conservation; Dr. Benjamin Tuggle, Division of Resource and Habitat Conservation; Mr. John Cooper, of the Branch of Habitat Assessment. Numerous personnel from the National Wetlands Inventory Center in St. Petersburg, FL. helped with data preparation, collection and field reconnaissance.

Technical review of the manuscript was provided by the following experts: Mr. William Ainslie, Chief, Wetlands Section, U.S. Environmental Protection Agency, Atlanta, GA; Dr. Ken Burnham Cooperative Research Unit, Colorado State University, Ft. Collins, CO; Mr. John Hefner, Ecological Services, U.S. Fish and Wildlife Service, Atlanta, GA; Dr. Wiley Kitchens, Florida Cooperative Fish and Wildlife Research Unit, University of Florida, Gainesville, FL.; Mr. Andreas Mager, Jr., Assistant Regional Administrator, Habitat Conservation Division, NOAA–National Marine Fisheries Service, St. Petersburg, FL; and Mr. Steve Rockwood Waterfowl Biologist, Florida Fish and Wildlife Conservation Commission, Fellsmere, FL.

The author and U.S. Fish and Wildlife Service wish to acknowledge Richard Young*, Cartographer, who was responsible for digital data verification and who produced many of the data tables and Geographic Information System graphics in this report.

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All photographs are by the author unless otherwise noted. Publication layout and final illustration of the report were done by Ms. Elizabeth Ciganovich, and photographs were revised by Ms. Marta Anderson and Ms. Erinn Dornaus, U.S. Geological Survey, Cartography and Publishing Program, Madison, WI.

This report should be cited as follows:

T. E. Dahl. 2005. Florida's wetlands: an update on status and trends 1985 to 1996. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. 80 pp.

Cover photograph: Forested wetland, Collier County, Florida.

Conversion Table

U.S. Customary to Metric

inches (in.)	x	25.40	=	millimeters (mm)
inches (in.)	x	2.54	=	centimeters (cm)
feet (ft)	x	0.3048	=	meters (m)
miles (mi)	x	1.609	=	kilometers (km)
nautical miles (nmi)	x	1.852	=	kilometers (km)
square feet (ft^2)	x	0.0929	=	square meters (m^2)
square miles (mi^2)	x	2.590	=	square kilometers (km^2)
acres (A)	x	0.4047	=	hectares (ha)
gallons (gal)	x	3.785	=	liters (L)
cubic feet (ft^3)	x	0.02831	=	cubic meters (m^3)
acre-feet (A-ft)	x	1233.5	=	cubic meters (m^3)
ounces (oz)	x	28.3495	=	grams (g)
pounds (lb)	x	0.4536	=	kilograms (kg)
short tons (tons)	x	0.9072	=	metric tons (t)
British Thermal Units (BTU)	x	0.2520	=	kilocalories (kcal)
Fahrenheit degrees (F)	→	0.556 (F - 32)	=	Celsius degrees (C)

Metric to U.S. Customary

millimeters (mm)	x	0.03937	=	inches (in.)
centimeters (cm)	x	0.3937	=	feet (ft)
meters (m)	x	3.281	=	feet (ft)
kilometers (km)	x	0.6214	=	miles (mi)
square meters (m^2)	x	10.764	=	square feet (ft^2)
square kilometers (km^2)	x	0.3861	=	square miles (mi^2)
hectares (ha)	x	2.471	=	acres (A)
liters (L)	x	0.2642	=	gallons (gal)
cubic meters (m^3)	x	35.31	=	cubic feet (ft^3
cubic meters (m^3)	x	0.0008110	=	acre-feet (A-ft)
milligrams (mg)	x	0.00003527	=	ounces (oz)
grams (g)	x	0.03527	=	ounces (oz)
kilograms (kg)	x	2.2046	=	ounces (oz)
metric tons (t)	x	2204.62	=	pounds (lb)
metric tons (t)	x	1.102	=	short tons (tons)
kilocalories (kcal)	x	3.968	=	British Thermal Units (BTU)
Celsius degrees (C)	→	1.8 (C) + 32)	=	Fahrenheit degrees (F)

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Executive Summary

Before Florida became a State in 1845, there were an estimated 20.3 million acres (8.2 million ha) of wetlands. Over time, wetlands have been drained, dredged, filled, leveled, and flooded to the extent that about half of the original wetland acreage remained.

The U.S. Fish and Wildlife Service has produced a series of status and trends reports on Florida's wetlands. The first (Hefner 1986) estimated the rate of wetland conversion to have been 72,000 acres (29,150 ha) per year between the mid 1950s and the mid 1970s. Those estimates captured trends from the period preceding efforts to protect and restore wetlands. Society's views about wetlands have changed considerably and interest in the preservation of wetlands has increased as the values of wetlands have become more fully understood. This became evident in the Service's updated wetlands status and trends report for Florida (Hefner and Frayer 1991) that covered the period from the mid 1970s to the mid 1980s. During that period the estimated rate of wetland loss had declined to 23,700 acres (9,600 ha) per year.

The Emergency Wetlands Resources Act (Public Law 99–645) was enacted to promote the conservation of our Nation's wetlands. The Act required the Service to conduct wetland status and trend studies of the Nation's wetlands at periodic intervals. This report has been produced as a supplemental effort and details the status and trends of Florida's wetlands from 1985 to 1996. It has provided the most recent and comprehensive estimates of the status and trends of wetland habitats within the State.

An interagency group of statisticians developed the design for the national status and trends study. Within Florida, the study design was stratified, random sampling with 636 randomly selected sample plots, each four square miles (2,560 acres or 1,040 ha) in area. These plots were examined, using remotely sensed data in combination with field work, to determine wetland change. Twenty two percent of the plots were field verified, and rigorous quality control measures were taken to ensure data integrity and quality. Estimates of changes over time were made for wetland area and by wetland type.

The study incorporated all wetlands, regardless of land ownership, as part of the sampled landscape. Because wetlands in coastal areas are important to a variety of fish and wildlife, a supplemental sampling stratum was added along the Atlantic and Gulf coastal fringes.

Determining what caused wetland loss or gain was an important part of assessing the effectiveness of policy or management actions. As part of this study, the Service worked with other Federal agencies to examine and field test wetland loss and gain attribution categories which included upland urban development, upland agriculture, upland silviculture, upland rural development, and other miscellaneous lands.

Corkscrew Swamp, Collier County, Florida.

Status of Wetlands in Florida, 1996

Florida's wetlands included coastal estuaries, mangrove islands, wet prairies, freshwater springs, cypress swamps, cattail marshes and many other types. Wetlands were found throughout the State from the Dry Tortugas to the Okefenokee Swamp along the Georgia border and from Cape Canaveral to the Gulf Islands near Pensacola.

In 1996, an estimated 11.4 million acres (4.6 million ha) of wetlands found in Florida occupied approximately 29 percent of area of the State, a greater percentage of the land surface than any other state in the conterminous United States.

Ninety percent of Florida's wetlands by area were freshwater systems. The remaining 10 percent were marine or estuarine intertidal wetlands. Of the original wetland area in Florida, about 56 percent remained.

The estimated average annual rate of wetland loss was 5,000 acres (2,030 ha) between 1985 and 1996. This was an 81 percent decline in the annual rate of loss as reported for the 1970s to 1980s. Important factors that contributed to the decline in the wetland loss rate included Federal, State and local legislation, ordinances and initiatives that protected wetland habitats, the application and enforcement of wetland protection measures, elimination of some incentives for wetland drainage, public education and outreach about the value and functions of wetlands, private land initiatives, coastal monitoring and protection programs, and programs and policies that promoted wetland restoration and creation.

Marine and Estuarine Wetlands

An estimated 314,400 acres (127,290 ha) of estuarine emergent or saltmarsh wetlands, 616,300 acres (249,510 ha) of estuarine shrubs and 206,400 acres (83,560 ha) of estuarine and marine nonvegetated vegetated wetlands occurred in Florida. These nonvegetated wetlands were commonly referred to as shores, sand or mud flats, bars and shoals.

Florida's coastal zone contained about 21 percent of all estuarine and marine wetlands found in the conterminous United States. A high percentage (92 percent) of estuarine shrub wetlands found in the conterminous U.S. were located in Florida, whereas only 8 percent of the estuarine emergent (salt marsh) wetlands were found along the State's coast lines. An estimated 31 percent of all nonvegetated estuarine and marine habitats within the conterminous United States were found in Florida.

The mean size of emergent salt marsh wetlands and estuarine shrub wetlands in the sample sites were slightly less than 23 acres (9 ha). The estuarine nonvegetated wetlands sampled averaged just over 10 acres (4 ha).

Florida's intertidal wetlands sustained a net loss of 500 acres (200 ha) or less than 1 percent during this study period. Compared with the results from the 1970s to 1980s, there was an 83 percent decline in the loss rate of marine and estuarine wetlands.

The estimated loss of 17 acres (7 ha) of estuarine emergent wetland to upland was statistically insignificant. Seventy five percent of the estuarine shrub losses were attributable to some form of coastal development. This may have involved construction of bridges, roadways, urban or suburban development or other infrastructure. Twenty percent of the estuarine shrub losses were attributed to agriculture and 5 percent were due to other unidentified upland land uses.

Seventy-one percent of the losses to estuarine shores was attributed to urban expansion along the coast. The remaining 29 percent was due to expansion of other unidentified types of upland land use.

The conversion of marine and estuarine wetlands to deepwater habitats involved losses to open water bay bottoms (deep water estuaries), or open ocean.

Freshwater Wetlands

There were an estimated 10.2 million acres (4.1 million ha) of freshwater wetlands in Florida in 1996. Freshwater wetlands made up 90 percent of all wetland area in the State. An estimated 98 percent were vegetated while the remaining 2 percent were open water ponds.

Within the freshwater system, approximately 5.6 million acres (2.3 million ha) were forested wetlands, 1.8 million acres (725,000 ha) were shrubs, 2.6 million acres (1.1 million ha) were emergent wetlands or marshes and 241,000 acres (98,000 ha) were freshwater ponds.

The size of freshwater wetlands in this study indicated forested wetlands were larger than shrubs or emergent wetlands. Forested wetlands averaged 17.7 acres (7 ha) with emergent marshes and shrub wetlands each averaging 9.9 acres (4 ha) and 7.1 acres (3 ha) respectively. The mean size of freshwater ponds was 1.7 acres (0.7 ha).

Florida's freshwater wetlands declined by an estimated 52,000 acres (21,100 ha) or 0.5 percent between 1985 and 1996. This was an average annual net loss of 4,740 acres (1,920 ha) and represented an 82 percent decline in the rate of loss since the 1970s to 1980s era.

Freshwater vegetated wetlands declined by an estimated 91,000 acres (36,800 ha) or 0.9 percent. Freshwater emergent wetlands exhibited the largest losses declining by an estimated 260,000 acres (10,500 ha) or 9.0 percent. These losses were partially offset by gains in other freshwater wetland types.

Freshwater forested wetlands exhibited a net gain over the course of this study. This was in contrast to long term trends which had exhibited continual decline since the 1950s. There was an estimated net gain of 22,500 acres (9,100 ha) due in large part to the maturation of shrub wetlands reclassified as forested wetlands. Forested wetland gains resulted from the conversion of almost 300,000 acres (118,500 ha) of shrub wetland to forested wetland. The vast majority of these lands were in production of wood products for lumber, pulp, chip and paper products.

There were an estimated 1,791,100 acres (725,140 ha) of wetland shrubs in 1996. This represented a gain of an estimated 146,400 acres (59,300 ha) or almost 9 percent. There was a close interrelationship between wetland shrub acreage and wetland forest acreage as many areas were rotating from shrub to forest following timber cutting. There was also a large amount of emergent wetland (306,000 acres or 123,900 ha) that was converted to shrub wetland during this study period.

From the 1970s to 1980s, the estimated loss of freshwater emergent wetlands was 110,000 acres (44,500 ha). This study indicated the loss rate of freshwater emergent wetland more than doubled as an estimated 260,200 acres (105,340 ha) were lost in Florida between 1985 and 1996. The conversion of freshwater emergent wetland to shrub wetland involved 286,900 acres (116,150 ha). Changes of the magnitude that occurred in Florida between 1985 and 1996 were indicative of prolonged periods of drought that allowed woody plants to become established in emergent wetlands, or the invasion of shrubs such as Brazilian Pepper or *Melaleuca*.

Freshwater ponds increased in area by over 39,000 acres (15,800 ha), almost 20 percent. Forested wetland area increased slightly (0.4 percent) while shrub wetlands increased by an estimated 8.9 percent. These gains largely overshadowed the losses to freshwater emergents.

Attribution of Wetland Losses

Net losses of wetland between 1985 and 1996 were attributed to urban and rural development, (72 percent) and agriculture (28 percent). Small net gains were recorded from silviculture and the "other uplands" land use categories.

Urban development destroyed a variety of freshwater wetland types. Losses attributed to urban expansion were fairly evenly divided between freshwater forested, shrub and emergent wetlands.

Loss of wetlands to urban and rural development involved drainage for homes, resorts, golf courses, industry, roads, bridges and other infrastructure. It occurred in high growth areas throughout the State. Collectively urban and rural development activities accounted for an estimated 72 percent of the net wetland losses.

Development outside established urban areas was termed rural development and included road construction, buildings for homes or industry, mining operations, golf courses, etc. Rural development was responsible for more freshwater forested wetland loss than other land use categories. An estimated 26,400 acres (10,700 ha) of forested wetlands were lost to rural development

Much of the wetland acreage loss to agriculture occurred in southern Florida where freshwater emergent wetlands were converted to citrus production, horticulture, growing landscape or other ornamental plants, greenhouses, sod farms and other agricultural uses. The net losses attributed to agriculture declined by 79 percent compared to the estimated losses attributed to agriculture from the 1970s to 1980s. There were an estimated 127,940 acres (51,800 ha) of wetlands that were restored or created from uplands. Approximately 67 percent took place on agricultural lands. Agricultural programs that promote wetland restoration, pond creation and land retirement were responsible for these gains.

St. Marks National Wildlife Refuge, an emergent marsh on Florida's Gulf Coast.

Introduction

The mission of the U. S. Fish and Wildlife Service is to conserve, protect, and enhance fish and wildlife and their habitats for the continuing benefit of the American people. The Service has responsibility for the protection and stewardship of endangered wildlife, migratory birds, certain marine mammals, and their habitats. Changes in the status of wetlands potentially affects migratory and endangered species. Florida's coastal, inland waters and wetlands provide habitats for a large number of resident species and are the wintering destination for many other migratory species. Approximately 75 species of mammals, 283 species of birds, 122 reptiles, 57 amphibians and 126 fishes can be found in the State (Millsap *et al.* 1990). Forty two of these species are listed as endangered by the U. S. Fish and Wildlife Service. The Florida panther (*Felis concolor coryi*), West Indian manatees (*Trichechus manatus*) and five species of sea turtles are critically endangered and require Federally designated species coordinators.

Wetlands support Florida's fish and wildlife populations. Coastal beaches provide nesting habitat for thirteen species of shorebirds and about 90 percent of all loggerhead sea turtles nesting in the United States (U.S. Fish and Wildlife Service 1996). Estuaries and near shore habitats are nurseries for ecologically and economically important fish and shellfish. Herons, egrets, ibises, spoonbills and storks reside in wetlands and are a conspicuous part of Florida's wildlife resources (Runde 1991). Seventeen percent of Florida's wildlife species are not found elsewhere in the United States. Some portions of south

Florida wetland wildlife, below from left to right: whooping crane (Grus americana), manatee (Trichechus manatus), great egret (Ardea alba), wood stork (Mycteria americana), green tree frog (Hyla cinera), and loggerhead turtle (Caretta caretta).

Shrimping boats and fisherman in Florida. (Photos courtesy of National Oceanic and Atmospheric Administration.)

Florida support the only subtropical ecological communities in the continental U.S. making it one of North America's most important reservoirs of biological diversity.

People also benefit from Florida's abundant wetland and water resources. Much of the State's tourist industry is based on the ability to access and enjoy coastal waters and beaches. Inland waters support sport fishing, canoeing, boating and other water sports. Wetlands provide opportunities for viewing and photographing nature, birdwatching, hunting and other outdoor activities. Other products produced by wetlands are used by industry or commercial enterprises. Coastal waters support commercial and recreational fisheries. Cypress mulch and peat are used for horticultural purposes, timber products for construction and manufacturing, mineral extraction and freshwater supplies are all be associated with wetlands in Florida.

The Emergency Wetlands Resources Act of 1986 (Public Law 99–645) was enacted to promote the conservation of our Nation's wetlands. The Act requires that the Fish and Wildlife Service conduct wetland status and trend studies of the Nation's wetlands at periodic intervals. This is accomplished by the use of a stratified, random sampling design where sample plots are examined with the use of remotely sensed imagery, in combination with field work, to determine wetland change. The most recent study detailed the status and trends of our Nation's wetlands from 1986 to 1997 (Dahl 2000). It provided the most comprehensive estimates of the current status and trends of wetland habitats. Although designed as part of the national assessment, the data collected as part of that effort meet criteria for providing statistical estimates of wetland status and trends for the State of Florida. The following sections report the results of the Florida data analysis.

Previous Service reports on Florida's wetland trends have used a similar subset of the national status and trends data set (Hefner and Brown 1984; Hefner 1986; Frayer and Hefner 1991). Those reports examined Florida's wetland trends from the 1950s to 1970s, and from the 1970s to 1980s, respectively. Data from those studies indicated that Florida had lost substantial wetland acreage. The cypress strands fringing the Atlantic coastal ridge, the pond apple forests south of Lake Okeechobee and the tropical hardwood hammocks were some of the wetland types that had been greatly reduced over time (U.S. Fish and Wildlife Service 1996). These types, once conspicuous and expansive landscapes, were reduced to highly fragmented remnant ptaches in South Florida (Davis and Ogden 1994).

With the advent of measures to conserve wetlands during the 1970s and 1980s, Florida's wetland loss rates declined (Frayer and Hefner 1991). However, since that time, the population has continued to increase dramatically. Florida ranked seventh in the Nation for population growth between 1990 and 2000. This growth has necessarily been accompanied by extensive land-use changes and increasing demand for water, resources and space. In addition, invasive species have spread, compromising the function and value of wetlands and waterways throughout the state. The presence of invasive species in wetlands and waterways has been problematic, and reconciling increasing demands for water resources has continued as an issue in Florida. These circumstances, accompanied by extensive land use changes, have generated continued interest in the status of the State's wetlands. Many challenges to maintaining wetland habitat availability and quality remain.

This report presents the latest wetland status information on Florida's wetland resources and provides estimates of losses or gains that occurred between 1985 and 1996. The data for the State were the first to be analyzed beyond the national data set and provide new information about wetland trends specific to Florida. These data have been supplemented with additional sources of information on wetland community types to provide a more comprehensive understanding of Florida's wetland resources.

Study Area and Procedures

A combination of geological history, climate, geography, environmental forces and human habitation have shaped Florida's landscape. Florida's 8,400 miles (5,220 km) of coastline, 13 river basins and nearly 8,000 lakes have been vital to the state's recreation and tourism industry (GAP Commission 2001). Water has been key to many of Florida's unique ecosystems. Coastal estuaries, mangrove islands, wet prairies, freshwater springs, cypress swamps, cattail marshes and many other types were found throughout the State from the Dry Tortugas to the Okefenokee Swamp along the Georgia border and from Cape Canaveral to the Gulf Islands near Pensacola (Figure 1).

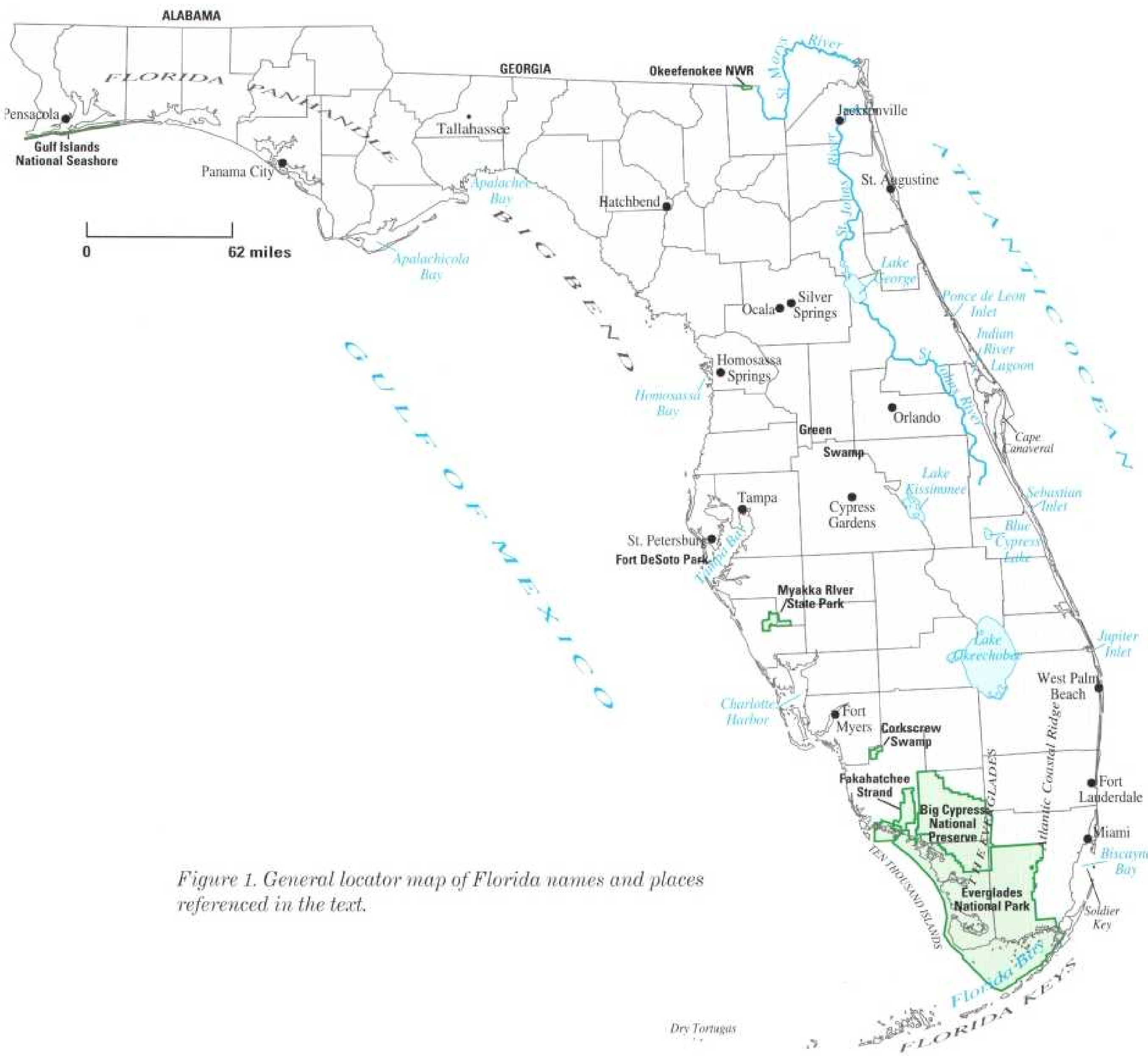


Figure 1. General locator map of Florida names and places referenced in the text.

The total land area of Florida was approximately 58,560 square miles (151,670 sq. km)[1]. Florida's mean elevation was 100 ft. (31 m) (Sharp 1992). Throughout south Florida and in the coastal stretches of the Big Bend area, relief of less than 6 feet (2 m) was widespread (Fernald and Purdum 1992). The landscape included coastal estuaries, beach and dune complexes, dense subtropical vegetation in the south and temperate hardwood forests in the north. Karstic (i.e. limestone) relief features including caves, sinks and low hills occurred in the north western portion of the State. Water bodies, whether they were coastal or inland were common, and no portion of the State was more than 60 miles (97 km) from salt water (Marth and Marth 1992). Florida was considered the wettest State with more wetland and surface water area than other States in the conterminous U.S. (Dahl 1990).

For this study, Florida was stratified into three physiographic regions (Figure 2). These included:

[1]This study incorporated some estuarine embayments not included in the total land area figure.

The Myakka River.

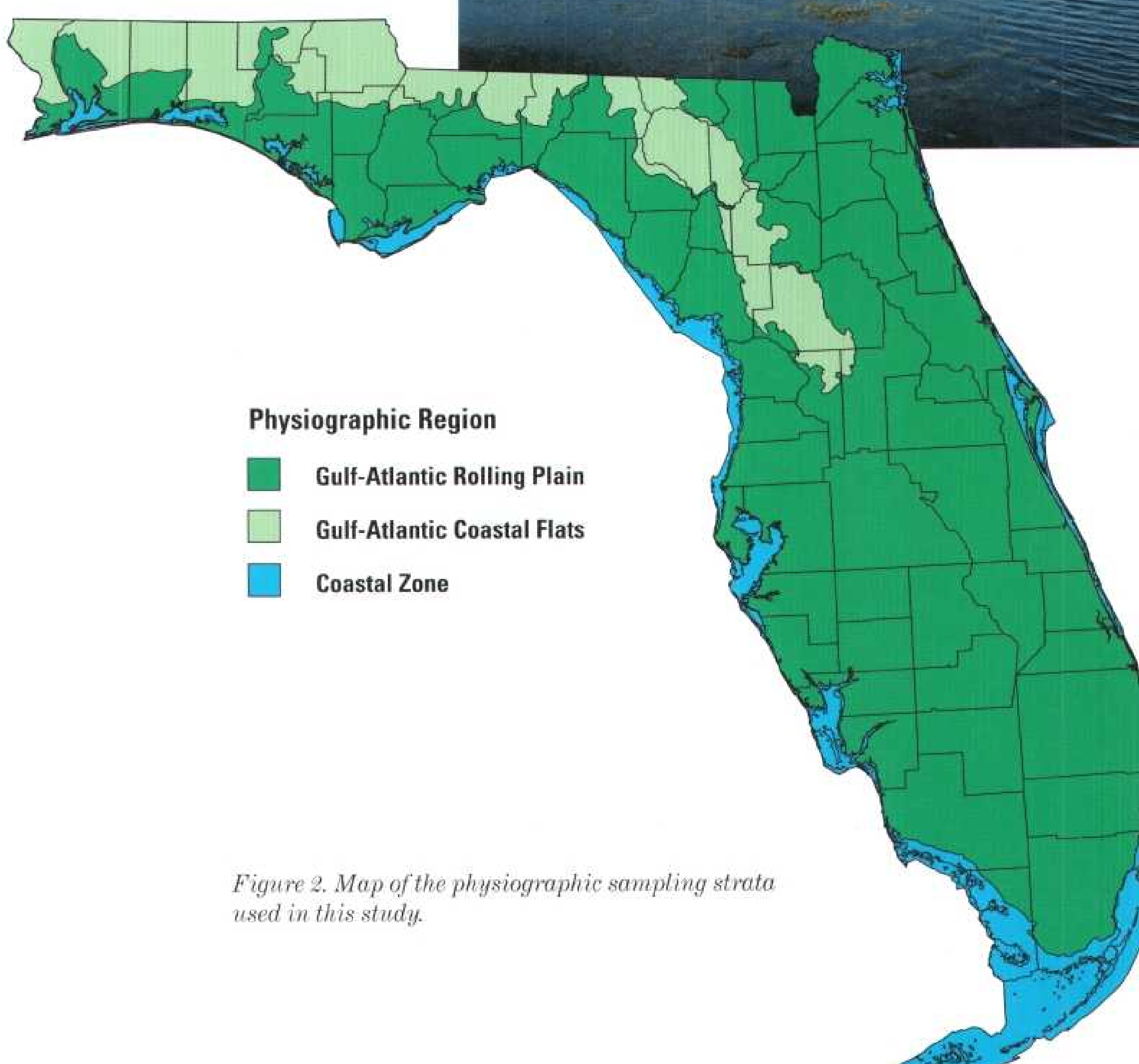


Figure 2. Map of the physiographic sampling strata used in this study.

Figure 3. Exposed tidal flats of an intertidal estuarine wetland in Wakulla County, Florida, 1993.

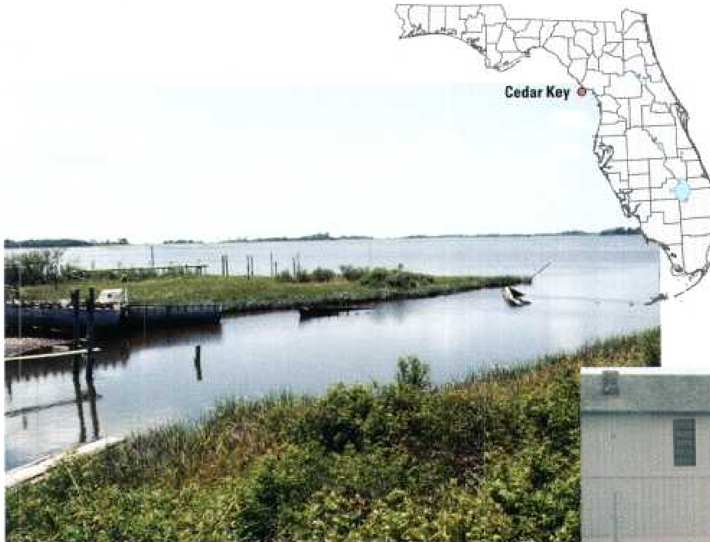
Coastal Zone

The Coastal Zone encompassed the near-shore areas of Florida and included barrier islands, coastal marshes, exposed tidal flats (Figure 3) and other features not in the landward physiographic zones. The Coastal Zone represents an area where salt water was the overriding influence on biological systems and was not synonymous with any State or Federal jurisdictional coastal zone definitions.

Florida had 8,426 miles (13,557 km) of tidal shoreline bordering both the Atlantic Ocean and the Gulf of Mexico. Included as part of this coastline were 700 miles (1,126 km) of sand beaches and 4,510 islands 10 acres (4.1 ha) or larger (Morris 1991).

Few rock shorelines occurred along the Florida coast. These were high energy intertidal environments where beach or coral had weathered to form irregularly shaped rocky features 1–3 meters high (Duever *et al.* 1982). Rock shoreline stretched discontinuously from south of St. Augustine to Jupiter Inlet. Rocky shores were also found on the windward side of some of the Florida Keys.

There were numerous islands that formed barriers between the Atlantic Ocean, the Gulf of Mexico and the mainland. Some segments of Florida's barrier islands have been designated as part of the Federal Coastal Barrier Resources System. The Barrier Islands Act of 1983 removed undeveloped islands from Federal flood insurance protection and resulted in 33 locations being designated as coastal barriers under this legislation. The system was expanded to include several more sites by the Coastal Barrier Improvement Act of 1990 (U.S. Dept. of Interior 1995). In all, 67 sites encompassing 285,146 acres (115,444 ha) of coastal island segments were designated as part of this system in Florida (Figure 4).



Cedar Key

Coastal vacation and residential development, Indian Rocks Beach

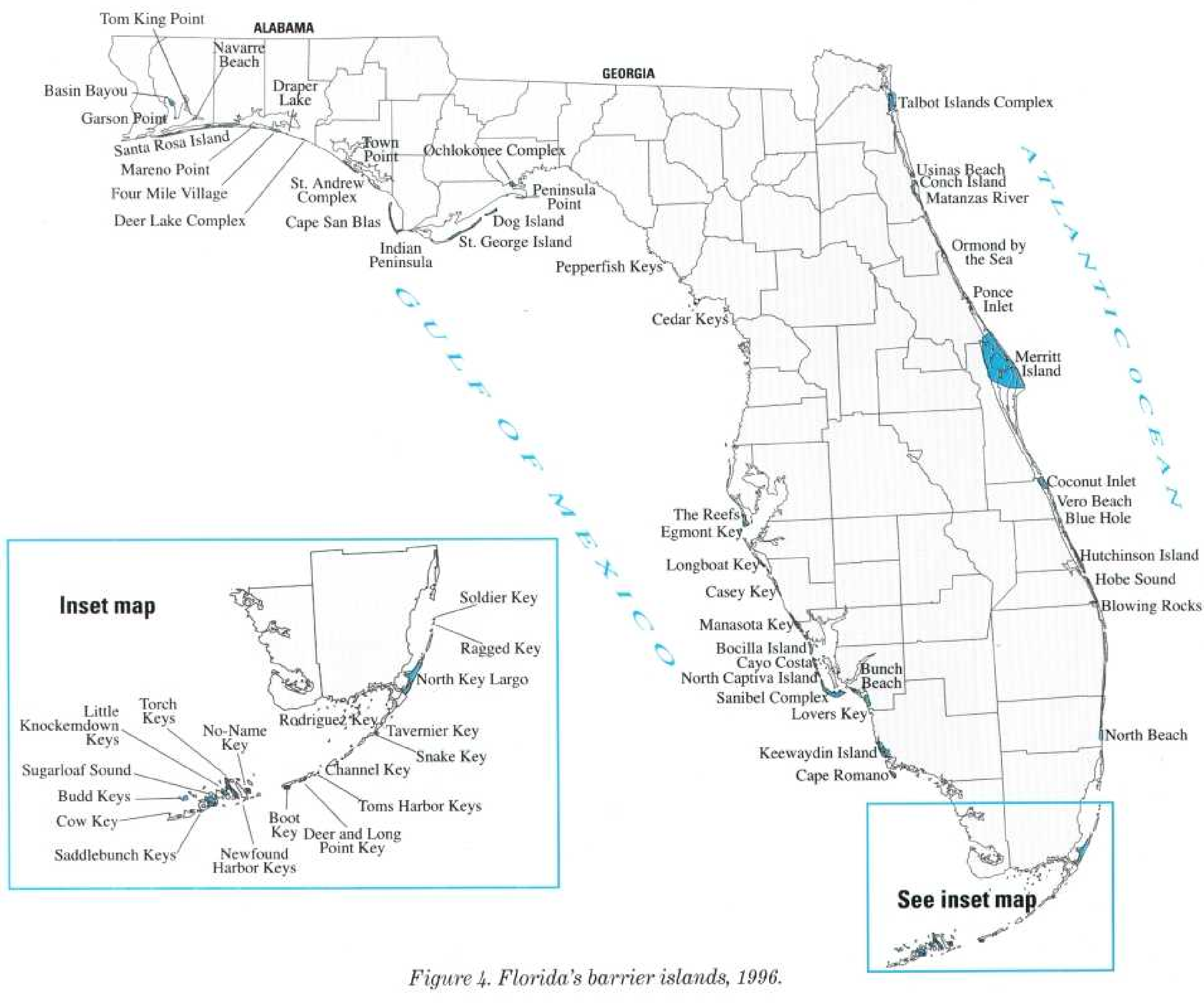


Figure 4. Florida's barrier islands, 1996.

Gulf-Atlantic Coastal Flats

The Gulf-Atlantic Coastal Flats physiographic region described by Hammond (1970), encompassed most of the Florida peninsula. The Coastal Flats were characteristically level, but low beach ridges provided some topographic relief as tree hammocks rose slightly above the surrounding landscape (Bailey 1980).

The Everglades covered much of south Florida. These vast wetlands occupied a flat marl and limestone shelf covered with shallow peat deposits (Figure 5). Elevations in the Everglades drainage system ranged from 14 feet (4.3 m) near Lake Okeechobee to sea level at Florida Bay. Slopes averaged less that 2 inches per mile (3 cm per km) as water flowed in a southwestern direction across the Everglades and into Florida Bay (McPherson and Halley 1996).

The Big Cypress Preserve, adjacent to the Everglades was made up of cypress strands, wooded sloughs and wet prairies (Duever *et al.* 1986).

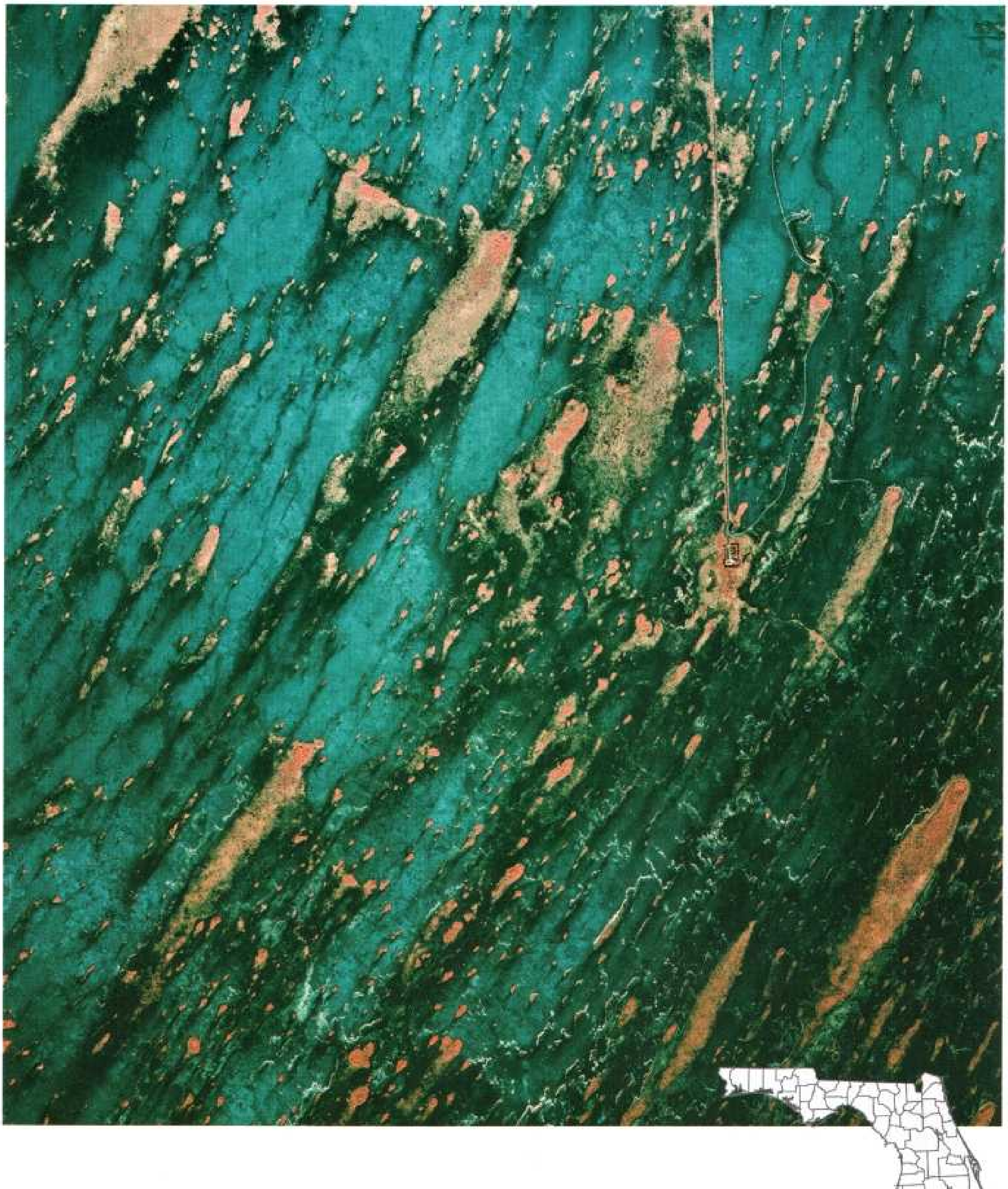


Figure 5. High altitude, color infrared photograph of a portion of Shark Valley, Florida Everglades, 1996. (Aerial photo courtesy of USGS.)

South and west of the Everglades and the Big Cypress Preserve are the Ten Thousand Islands. This area supported the most extensive mangrove swamp in the United States (U.S. Fish and Wildlife Service 1996). The mangrove islands were dissected by numerous tidal channels dotted with Indian mound hammocks of slightly higher elevation which support a variety of tropical trees (Figure 6). The Everglades, contiguous with the Big Cypress Preserve and the Ten Thousand Islands area, form one of the largest expanses of wetlands found in the conterminous United States.

The Gulf-Atlantic Coastal Flats also included many highly populated urban centers such as Miami/Ft. Lauderdale/West Palm Beach, Tampa/St. Petersburg, Ft. Myers, Orlando, Jacksonville and Pensacola. Much of Florida's citrus and vegetable crop were grown in this region of the State.

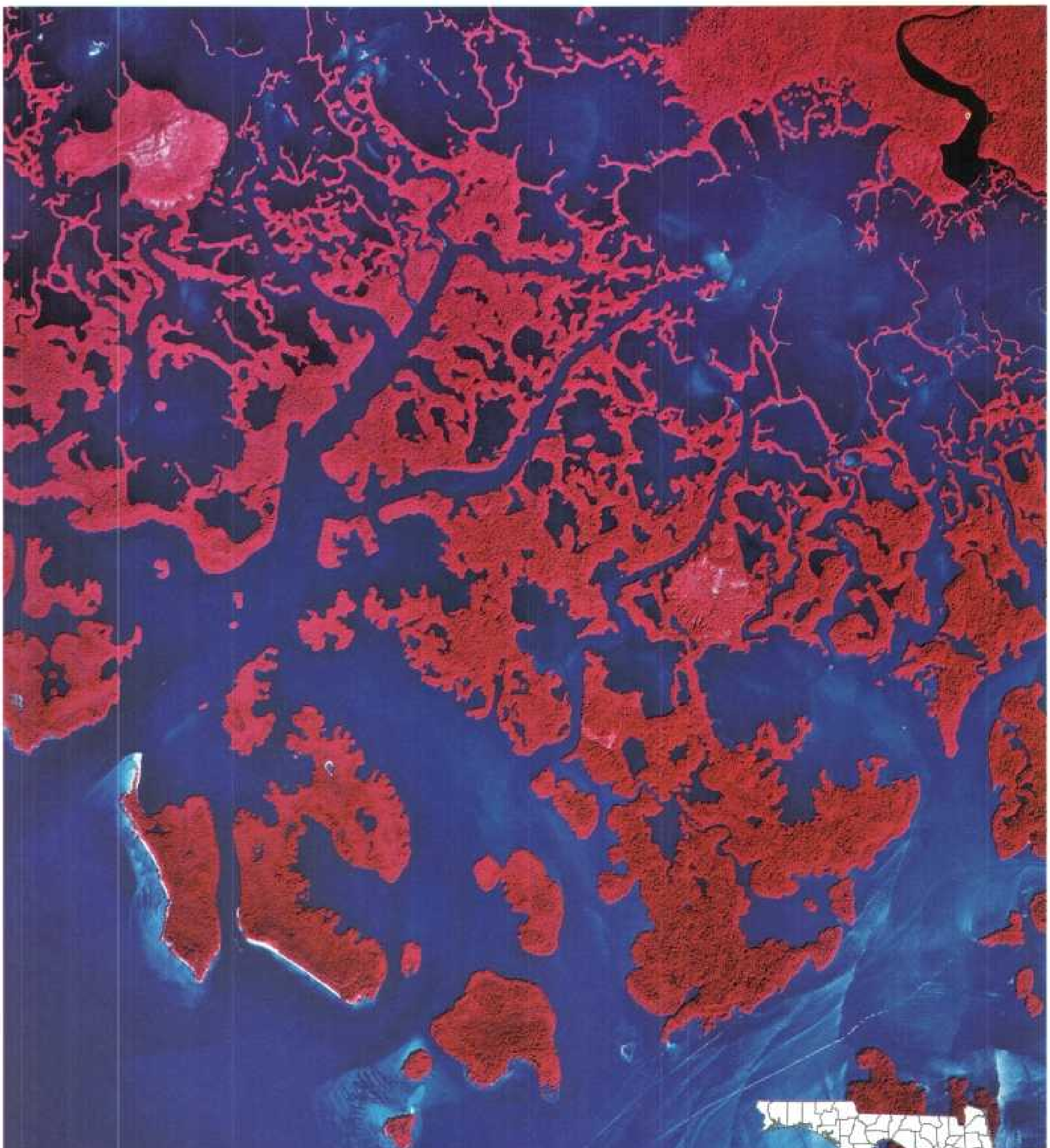


Figure 6. Mangrove islands (red) as shown on color infrared photography of Florida Bay, 1996. (Aerial photo courtesy of FL DEP.)

Gulf-Atlantic Rolling Plain

The Gulf-Atlantic Rolling Plain included a portion of the northern panhandle, and the northern part of peninsular Florida. It was contiguous with physiographic zones extending south from Alabama and Georgia. This region of the State, as delineated by Hammond (1970), was an area of slightly higher elevation and it supported largely temperate-zone vegetation (Duever *et al.* 1982). Omernik (1987) described similar physiographic settings as smooth to irregular plains with a mosaic of crop land, forest, pasture and urbanized areas.

Other Important Facets of Florida's Water Resources

Water has sustained many of the State's unique ecosystems and has been key to the recreation and tourism industry (Figure 7). Florida's 8,426 miles (5,220 km) of coastline provide vast socioeconomic value as well as important ecological resources.

There were 34 major river systems in Florida (Marth and Marth 1992). Collectively, there were 1,711 rivers and streams that made up an estimated 10,550 miles (16,975 km) of flowing water systems in Florida (Morris 1991). Alluvial rivers originating in piedmont Alabama and Georgia and running south through the Florida panhandle carried sediments made up of sand, silt or clays. Others originiating in the coastal plain are dominated by base flows. Examples include the Suwannee and St. Johns Rivers where waters were often colored black from the high levels of tannic acid in the runoff from surrounding swamp hardwoods. (The wetlands surrounding these rivers were often referred to in colloquial terms as "red river bottoms" or "red river swamp" and "black water river bottoms" depending on the origins

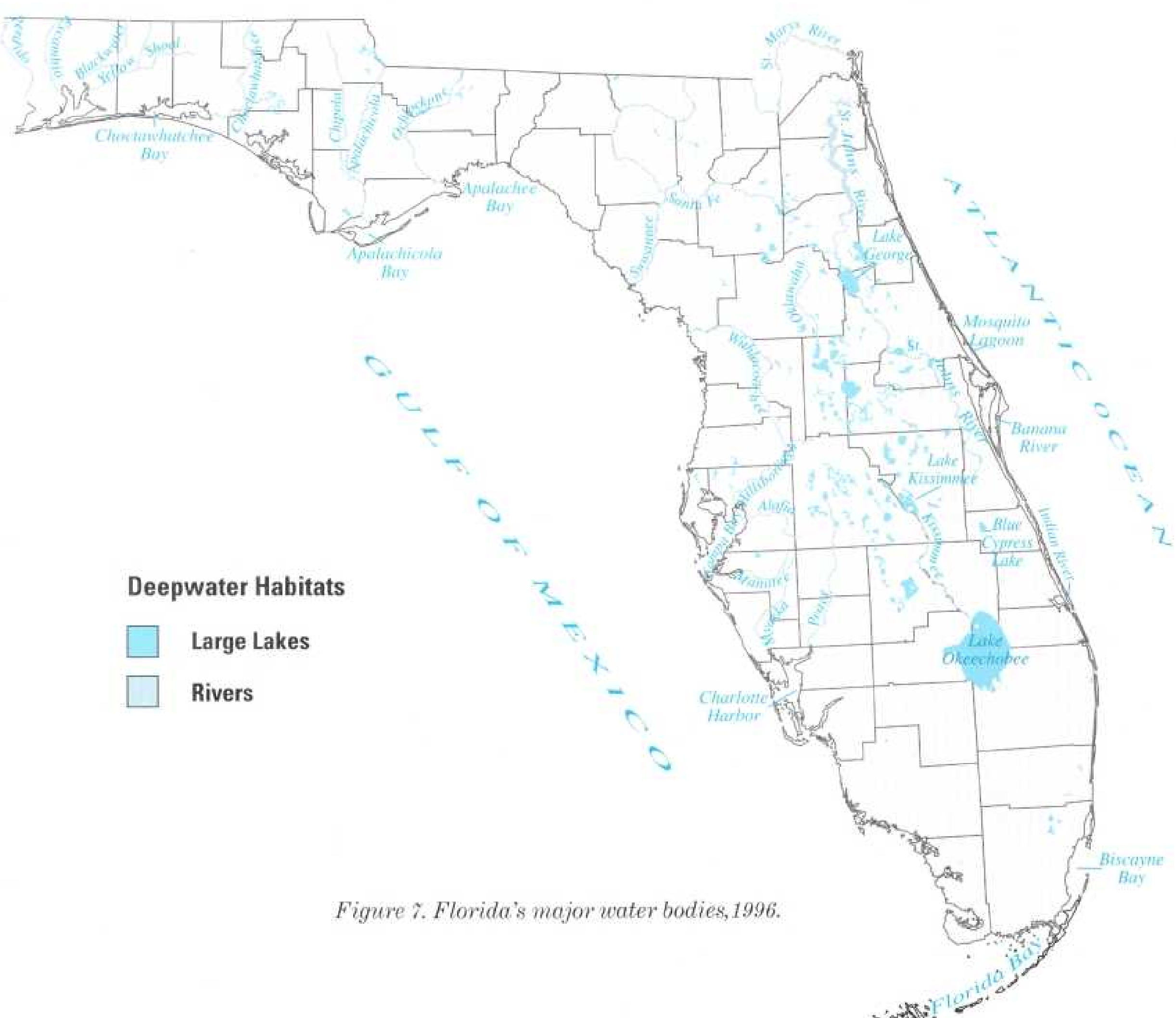


Figure 7. Florida's major water bodies, 1996.

of the river water.) The wetlands adjacent to these rivers provide food chain support, fish and wildlife habitat, erosion control, water quality protection, flood storage and control and deep aquifer recharge (Taylor *et al.* 1990).

Other freshwater resources included 7,800 lakes, nearly all naturally formed from sink holes or solutional depressions. Lake Okeechobee is the Nation's second largest freshwater lake wholly within the U.S. borders. Geologists have estimated that Florida may have nearly 600 freshwater springs (Figure 8), a number classified as first magnitude springs with average flows of greater than 100 cubic feet/sec (2.8 cubic meters/sec) (Morris 1991).

There were 67 counties in Florida (Figure 9). Between 1990 and 2000 Florida's population increased by 23.5 percent making it the fourth most populous state in the Nation (U.S. Census Bureau 2002). Tourism was the leading industry, agriculture was second as Florida was one of the top producers of citrus, sugarcane, tomatoes, foliage, honey and strawberries (Marth and Marth 1992).

Figure 8. Freshwater springs near Ocala, Florida, 1993.

Figure 9. Florida counties, 1996.

Study Methods

Wetland Definition and Classification

Cowardin *et al.* (1979) was used to define wetland for this study. This ecological definition was the National standard for wetland mapping, monitoring and data reporting as determined by the Federal Geographic Data Committee. It was a two-part definition as indicated below:

Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water.

For purposes of this classification, wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes, (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.

Habitat category definitions used in this study appear in synoptic form in Table 1. Complete definitions of wetland types and land use categories used to conduct this study are in Appendix A.

Study Design

Within the physiographic regions described above, sample plots were randomly allocated in proportion to the amount of wetland acreage expected to occur within each stratum. Each sample plot was 2.0 miles (3.218 km) on a side, or 4 square miles total area equaling 2,560 acres (1,036 ha). Six-hundred-and-thirty-six sample plots were analyzed in this study (Figure 10). For each sample plot, aerial photography (i.e. digital orthophoto quarter quadrangle) was acquired and interpreted to identify wetlands, deepwater habitats and uplands. Plots were initially allocated to strata based on the best information available about wetland area and variability by strata and on a standard optimal-allocation formula for stratified simple-random sampling. This stratification scheme had ecological, statistical, and practical advantages because the physiographic divisions within Florida coincided with factors that effected wetland distribution and

One of the world's largest and deepest freshwater springs, Wakulla Springs is a pristine river sanctuary.

Florida panther (Felis concolor coryi). (Photo courtesy of Everglades National Park.)

Table 1. Wetland, deepwater, and upland categories used in this study. The definitions for each category appear in Appendix A.

Category	*Common Description*
Salt Water Habitats	
Marine Subtidal*	Open ocean
Marine Intertidal	Near shore
Estuarine Subtidal*	Open water/bay bottoms
Estuarine Intertidal Emergents	Salt marsh
Estuarine Intertidal Forested/Shrub	Mangroves or other estuarine shrubs
Estuarine Unconsolidated Shore	Beaches/bars
Estuarine Aquatic Bed**	Submerged or floating estuarine vegetation
Riverine (may be tidal or nontidal)	River systems
Freshwater Habitats	
Palustrine Forested	Forested swamps
Palustrine Shrub	Shrub wetlands
Palustrine Emergents	Inland marshes/wet meadows
Palustrine Unconsolidated Shore	Shore beaches/bars
Palustrine Unconsolidated Bottom	Open water ponds
Palustrine Aquatic Bed	Floating aquatic/submerged vegetations
Lacustrine	Lakes and reservoirs
Uplands	
Agriculture	Cropland, pasture, managed rangeland
Urban	Cities and incorporated developments
Forested Plantations	Planted or intensively managed forests, silviculture
Rural Development	Nonurban developed areas and infrastructure
Other Uplands	Rural uplands not in any other category; barren lands

**Deepwater habitat*

***Technical limitations described in the text* abundance. Thus, this study design was well suited for determining wetland acreage and trends.

Wetland changes were determined by intensive analysis of the aerial photography (Figure 11), interpretation of wetland types and hydrologic conditions, and determination of the changes that occurred between the respective target dates. The mean dates of the aerial photography used to determine wetland trends were 1985 and 1996, with the difference being an average of 11 years. For this study, wetlands 3 acres (1.2 ha) and larger composed the target population. Actual results indicated that for each wetland category included in the study, the minimum size represented was less than 1.0 acre (0.4 ha). However, not all wetlands less than the target size category were detected.

Changes in areal extent or type of wetland observed on the sample plots between 1985 and 1996 were recorded. Field verification of features on the aerial photography was done for 138 plots or 22 percent of the total sample. Field verification addressed questions regarding image interpretation, land use coding, and attribution of wetland gains or losses. Field work was also done as a quality control measure to verify that plot delineations were correct. Verification involved field visits to a cross section of wetland types and geographical settings. Field work was used to update sample plots based on observations of on-the-ground conditions. Low level reconnaissance was done by helicopter for some plots inaccessible on the ground. Representatives from three Federal agencies (Natural Resources Conservation Service, Fish and Wildlife Service and U.S. Geological Survey) participated in field reconnaissance trips and quality control reviews from April 1999 through May 2000.

For each sample plot, the extent of change among all wetland types between the two dates of photography was used to estimate the total area of each wetland type. Areas of the sample plot that had been identified in previous eras as wetlands but that were no longer wetlands, were placed into five land use categories, which included agriculture, upland forested plantations, upland areas of rural development, upland urban landscapes and other miscellaneous lands. The outputs from this analysis were change matrices that provided estimates of wetland area by type and observed changes over time. The advantages of this design were that it focused entirely on

Figure 10. Sample plot distribution within Florida, 1996.

monitoring wetland change, it was used to monitor conversions between ecologically different wetland types, and it measured wetland gains and losses.

Advances in computerized cartography helped to reduce labor intensive tasks and to improve data quality and geospatial integrity. Newer technologies allowed the generation of existing digital plot files at any scale to directly overlay onto an image base. The wetlands interpreter viewed the new imagery and made change notations directly on the image overlay. This process was greatly facilitated by the use of rectified digital orthophoto quarter quadrangle imagery obtained with the assistance of the Florida Department of Environmental Protection. Because the plot information was already in a spatially rectified file, any change information could be inserted to the correct geospatial position in the plot boundary. Area information was recalculated from the new digital file by use of a geographic information system. This process eliminated manual drafting, registered the image overlays to georeferenced coordinates, and reduced imprecise lines (line pixel width) inherent in older scanning technologies.

Figure 11. Sample of 1996 color infrared aerial photography used to identify and classify wetlands. (Aerial photo courtesy of FL DEP.)

The geospatial analysis capability built into this study provided a complete digital database to better assist analysis of wetland change information. Rigorous quality control inspections were built into the interpretation, data collection and analysis processes. A more complete description of the techniques used to accomplish the interpretation, registration, and change detection is provided in various technical manuals (U.S. Fish and Wildlife Service 1994a, 1994b). Detailed discussion of the geographic information systems design, quality control procedures and the statistical aspects of the study design were presented by Dahl (2000).

This study produced estimates of total wetland area and changes for the State of Florida, and included all lands and waters of the State within the sampling frame, regardless of land ownership. Statistical estimates were used to expand the sample data to specific physiographic regions, wetland types or were generated for the entire State. The reliability of each estimate generated was expressed as the percent coefficient of variation (% C.V.) associated with that estimate. This study was designed to measure changes in wetland area without further assessment of species composition or wetland quality.

Study Limitations

Due to the limitations of using aerial photography as the primary data source to detect wetlands, certain habitats were excluded from this study by design. These included:

- **Small Limesinks or Limestone Sinkholes**—These cavities or depressions were variable in size and were associated with partially or completely collapsed limestone rock. They were considered a type of wetland if they were observed to hold standing water. Large limesinks or sinkholes were detected on the aerial photography and included in the study results based on their cover type. However, many limesinks were small (less than 1 acre or .5 ha), and tree canopies or other vegetation may have masked their presence. In these instances, sinkholes were excluded from the report analyses because they were not detectable.

- **Seagrasses or Submerged Aquatic Vegetation**—The detection of submerged aquatic vegetation was difficult using aerial photography without extensive surface-level observations, tide stage data, water clarity data and low surface waves (Ferguson *et al.* 1993). Seagrasses and other submerged plants inhabited the intertidal and subtidal zones of estuaries and near shore coastal waters (Orth *et al.* 1990). The four most common seagrasses found in Florida were widgeon grass (*Ruppia maritima*), shoal grass (*Halodule wrightii*), turtle grass (*Thalassia testudinum*) and manatee grass (*Syringodium filiforme*).

  Collectively, Florida had been reported to have between 1.9 and 2.7 million acres (769,230 to 1,093,100 ha) of seagrasses (Sargent *et al.* 1995). Florida's seagrasses were not delineated as part of this study.

- **Reefs**—Tropical reef communities (coral or tuberficid worm reefs) were found offshore

Unique coastal marsh ecosystem of Mashes Island County Park, Wakulla County, Florida.

in south Florida waters. These reefs range in water depth from less than 1 m to 41 m. Maximum coral reef development was restricted to the south and western portions of the State, along a line extending from Soldier Key to the Dry Tortugas (Jaap 1984). Oyster (*Crassostrea virginica*) reefs also occurred in the intertidal zone adjacent to marshes or mud flats (Bahr and Lanier 1981). There were also approximately 329 permitted artificial reefs in Florida coastal waters. Most of these occurred in deep water, however several were in 7 to 8 feet (2–2.5 m) of water (Pybas 1991).

Coral reefs were concentrated complexes of corals and other organisms that constructed a limestone structure in shallow waters (Jaap 1984). They were important links to a number of fishery and benthic marine resources and along with seagrasses and mangroves formed a vital component of the coastal ecosystem. The only emergent coral reefs found in the conterminous U.S. were located in the Florida Keys extending south from Miami and Soldier Key to the Dry Tortugas. This narrow band of shallow water (<10 m) reef habitat covered approximately 360 sq. km and was the planets third largest barrier reef system in the world (Miller and Crosby 1998). Coral reef extent and changes were not quantified as part of this study. Although data from other studies were available for only limited geographical sites, there has been widespread agreement that coral reef area has been declining (Millhouser *et al.* 1998).

- **Ephemeral Water**—When defining and classifying wetlands Cowardin *et al.* (1979) did not recognize ephemeral water areas as a wetland type. Therefore, ephemeral water areas were not included in this study.

Attribution of Freshwater Wetland Losses in Florida

The process of identifying or attributing cause for wetland losses or gains has been investigated by both the Service and the Natural Resources Conservation Service. During 1998 and 1999, the Natural Resources Conservation Service and the Service launched a concerted effort to develop a uniform system of definitions to attribute wetland losses and gains to their causes. The categories used to determine the cause of wetland losses and gains are described below.

Agriculture

The definition of agriculture followed Anderson *et al.* (1976) and included land used primarily for the production of food and fiber. Agricultural activity was shown by distinctive geometric field and road patterns on the landscape and/or by tracks produced by livestock or mechanized equipment. Agricultural land uses included horticultural crops, row and close grown crops, hayland, pastureland, native pastures and range land and farm infrastructures. Examples of agricultural activities within each land use included:

Horticultural crops consisted of orchard fruits (limes, bananas, grapefruit, oranges, peaches, avocados, other citrus and like species). Also included were nuts such as almonds, pecans and walnuts; vineyards including

The roseate spoonbill (Ajaia ajaja) prefers mangrove swamp and salt marsh habitats. (Photo courtesy of Everglades National Park.)

grapes and hops; bush-fruit such as blueberries; berries such as strawberries or raspberries; and commercial flower and fern growing operations.

Row and Close Grown Crops included field and sugar cane, sweet corn, sorghum, soybeans, cotton, peanuts, tobacco, sugar beets, potatoes, other truck vegetables including melons, beets, cabbage, cauliflower, pumpkins, tomatoes, sunflower and watermelon. Close grown crops also included wheat, oats, barley, sod, ryegrass, and similar graminoids.

Hayland and pastureland included grass, legumes, summer fallow and grazed native grassland.

Other farmland included farmsteads and ranch headquarters, commercial feedlots, greenhouses, hog facilities, nurseries and poultry facilities.

Forested Plantations

Forested plantations consisted of planted and managed forest stands and included planted pines, Christmas tree farms, clear cuts and other managed forest stands. These were identified by observing the following remote sensing indicators: 1) trees planted in rows or blocks; 2) forested blocks growing with uniform crown heights; and 3) logging activity and use patterns.

Rural Development

Rural developments occurred in rural and suburban settings outside distinct cities and towns. They were characterized by nonintensive land use and sparse building density. Typically, a rural development was a crossroads community that had a corner gas station and a convenience store and were surrounded by sparse residential housing. Scattered suburban communities located outside of a major urban centers were also included in this category as were some industrial and commercial complexes; isolated transportation, power, and communication facilities; strip mines; quarries; and recreational areas such as golf courses. Major highways through rural development areas were included in the rural development category.

Urban Development

Urban land consisted of areas of intensive use in which much of the land was covered by structures (high building density). Urbanized areas were cities and towns that provided goods and services through a central business district. Services such as banking, medical and legal office buildings, supermarkets and department stores made up the business center of a city. Commercial strip developments along main transportation routes, shopping centers, contiguous dense residential areas, industrial and commercial complexes, transportation, power and communication facilities, city parks, ball fields and golf courses were included in the urban category.

Other Land Uses

Other Land Use was composed of uplands not characterized by the previous categories. Typically these lands included native prairie, unmanaged or nonpatterned upland forests and scrub lands, and barren land. Lands in transition between different uses were also in this category.

Transitional lands were lands in transition from one land use to another. They generally occurred in large acreage blocks of 40 acres (16 ha) or more. They were characterized by the lack of any remote sensor information that would enable the interpreter to reliably predict future use. The transitional phase occurred when wetlands were drained, ditched, filled, leveled or the vegetation has been removed and the area was temporarily bare.

During April, 1999, cooperative interagency field evaluations were conducted to test the definitions used by the Service on the wetland status and trends plots to attribute wetland losses or gains. Field exercises involving the participation of the Service and the Natural Resources Conservation Service were conducted in central and south Florida. These exercises consisted of a careful review of determinations made on 31 sample plots. Field evaluation of these plots resulted in no disagreement among agency representatives with how the Service attributed wetland losses or gains as to cause.

Florida's Everlades during a dry season, 1990.

Table 2. Wetland habitat descriptions, characteristic plant species and classification designation(s) as found in this study.

Habitat—Community Type and Synonyms	*Description*	*Characteristic Plant Species*	*References*	*Designation for This Study*
		Coastal Zone		
Mangrove Forest—Mangrove Swamp; Shrub; Mangle; Tidal Swamp; Mangrove Islands	Salt tolerant trees that are adapted to continual flooding and salt water. Mangroves grow along low energy shorelines in the subtropical intertidal communities that tolerate very little frost. They are most common in the southern portions of the State particularly south of Charlotte Harbor, in the Ten Thousand Islands area and along Florida Bay.	Red mangrove (*Rhizophora mangle*) Black mangrove (*Avicennia germinans*) White mangrove (*Laguncularia racemosa*) Buttonwood (*Conocarpus erecta*)	Florida Natural Areas Inventory and Florida Dept. of Nat. Resources (1990), Florida Soil Conservation Service (1992), Odum *et al.* (1982), Odum and McIvor (1990), U.S. Army Corps of Engineers (1988).	Estuarine Shrub
Salt Marsh	Estuarine salt marshes are tidally flooded communities dominated by species of grasses, rushes or sedges that form along low wave-energy coastlines and river mouths. Marshes dominated by black needlerush (often in nearly pure stands) are most common growing on mud deposits flooded by high tide. They are found primarily from Apalachicola Bay south to Tampa Bay and form as much as 50 percent of Florida's salt marsh area. Smooth cordgrass is adapted to frequent tidal flooding and a saline environment. This species is prevelent in the coastal marshes along the Atlantic coast in the northeastern part of the State.	Black needlerush (*Juncus Roemerianus*) Smooth cordgrass (*Spartina alterniflora*) Seashore saltgrass (*Distichlis spicata*) Saltmeadow cordgrass (*Spartina patens*) Glasswort (*Salicornia spp.*) Saltwort (*Batis maritima*)	Carlton (1977), Dressler *et al.* (1987), Drew and Schomer (1984), Florida Natural Areas Inventory and Florida Dept. of Nat. Resources (1990), Montague and Wiegert (1990).	Estuarine Emergent
Brackish Marsh	These wetlands, composed of herbaceous species, are characterized by low or fluctuating salinity. These areas are subject to tidal influence as well as freshwater inflows such that neither estuarine nor freshwater plants attain full dominance.	Saltmeadow cordgrass (*Spartina patens*) Sea ox-eye (*Borrichia frutescens*) Saltmarsh aster (*Aster tennufolius*) Sawgrass (*Cladium jamaicense*) Bulrushes (*Scirpus spp.*) Big cordgrass (*Spartina cynosuroides*) Marshelder (*Iva frutescens*)	Carlton (1977), Florida Natural Areas Inventory and Florida Dept. of Nat. Resources (1990), Stout (1984), Wolfe *et al.* (1988).	Estuarine or Palustrine Emergent
Beach	Sand or mud beaches are nonvegetated wetlands periodically inundated by wave action between low and high tide. The sediments are usually sand or mud.	Nonvegetated	Gore (1992)	Estuarine or Marine Intertidal Unconsolidated Shore
Flats, Shoals, Bars	Tidal flats are composed of sand or mud found in hyper-saline conditions along the coast or on the landward side of barrier islands. Shallow water sand flats become exposed at low tide. They may become sparsely vegetated by scattered succulent halophytic forbs. Oyster bars develop in low-energy tidal areas with inflows of freshwater from sources such as rivers and tidal creeks. These areas are always nonvegetated and may become completely submerged at high tide.	Nonvegetated or sparsely vegetated flats: Saltwort (*Batis maritima*) Glasswort (*Salicornia spp.*) Salt grass (*Distichlis spicata*) Sea bite (*Suaeda linearis*) Nonvegetated, often partly submerged and dominated by the eastern oyster (*Crassostrea virginica*)	U.S. Army Corps of Engineers (1988).	Estuarine or Marine Intertidal Flats or Reefs

Table 2. Wetland habitat descriptions, characteristic plant species and classification designation(s) as found in this study—Continued.

Habitat—Community Type and Synonyms	*Description*	*Characteristic Plant Species*	*References*	*Designation for This Study*
		Coastal Zone—Continued		
Open Water Estuary	Deep water portion of bays, inlets or sounds	Nonvegetated	Bahr and Lanier (1981), Florida Natural Areas Inventory and Florida Dept. of Nat. Resources (1990).	Estuarine Subtidal
Open Ocean	Deep water	Nonvegetated		Marine Subtidal
		Coastal Flats and Rolling Plain		
Forested Wetland				
Cypress Ponds; Cypress Strand; Cypress Gall; Cypress Dome	Dome swamps or cypress ponds are characterized as shallow, usually circular or oval depressions dominated by cypress, black gum or tupelo. "Strands" refer to shallow elongated depressions or channels dominated by cypress trees. These wetlands are flooded for long periods during the year. They are common where high water tables and topographic depressions allow these wetlands to develop as isolated islands intermixed with pine flatwoods and pastures.	Bald cypress (*Taxodium distichum*) Pond cypress (*Taxodium asendens*) Black gum (*Nyssa sylvatica*) Water tupelo (*Nyssa aquatica*)	Darst *et al.* (1996), Ewel and Odum (1986), Lake County Water Authority (1995).	Palustrine (Freshwater) Forested
Hydric Hammock; Hardwood Hammock	This forested wetland type occurs at low elevations and usually on thin soils of sand and loam over limestone. They are most common in north and central Florida and support a diversity of plant species. These wetlands flood occasionally, but for short periods of time.	American elm (*Ulmus americana*) Red maple (*Acer rubrum*) Cabbage palm (*Sabal palmetto*) Sweet bay (*Magnolia virginiana*) Sweetgum (*Liquidambar styraciflua*) Water oak (*Quercus nigra*) Laurel oak (*Quercus laurifolia*) Box Elder (*Acer negundo*) Swamp ash (*Fraxinus pauciflora*)	Florida Natural Areas Inventory and Florida Dept. of Nat. Resources (1990), Vince *et al.* (1989), Simons *et al.* (1989), Ward (1943).	Palustrine (Freshwater) Forested
Bayheads	Bayheads are forested wetlands with a mix of broadleaf and evergreen bay tree species. They are almost continually saturated but may be inundated with shallow water. Soils of bayhead wetlands are organic and acidic.	Loblolly bay (*Gordonia lasianthus*) Swamp bay (*Persea borbonia*) Sweet bay (*Magnolia virginiana*) Sweetgum (*Liquidambar styraciflua*) Slash pine (*Pinus elliottii*) Black gum (*Nyssa sylvatica*) Willow (*Salix spp.*)	Florida Natural Areas Inventory and Florida Dept. of Nat. Resources (1990), Lake County Water Authority (1995), U.S. Army Corps of Engineers (1988).	Palustrine (Freshwater) Forested
Mixed Hardwood Swamp; Floodplain Swamp; Bottomland Swamp	These forested wetlands are dominated by deciduous tree species and are found in seasonally flooded basins, on flooded soils along river or stream channels and in depressions or oxbows within river floodplains. Soils are variable mixtures of sand, organic and alluvial sediments. Seasonal and often prolonged inundation is a characteristic.	Bald cypress (*Taxodium distichum*) Red maple (*Acer rubrum*) Dahoon holly (*Ilex cassine*) Pop ash (*Fraxinus caroliniana*) Cabbage palm (*Sabal palmetto*) Black gum (*Nyssa sylvatica*) Winged elm (*Ulmus alata*) Willow (*Salix spp.*) Sweetgum (*Liquidambar styraciflua*) Water oak (*Quercus nigra*) Overcup oak (*Quercus lyrata*) Water Tupelo (*Nyssa aquatica*) Water Hickory (Carya aquatica) Green Ash (*Faxinus pennsylvania*) Laurel oak (*Quercus laurifolia*)	Ewel (1990), Florida Natural Areas Inventory and Florida Dept. of Nat. Resources (1990), Ward (1943), Wolfe *et al.* (1988).	Palustrine (Freshwater) Forested

Table 2. Wetland habitat descriptions, characteristic plant species and classification designation(s) as found in this study—Continued.

Habitat—Community Type and Synonyms	*Description*	*Characteristic Plant Species*	*References*	*Designation for This Study*
		Coastal Flats and Rolling Plain—Continued		
Pine Flatwoods	Pine flatwoods may be Florida's most common ecological community. They occur on flat, poorly drained, sandy soils that are underlain by clay or hardpan. Wet pine flatwoods will have standing water for several weeks during the rainy season. In Florida, pine flatwoods may be a mixture of wetland and upland.	Long leaf pine (*Pinus palustris*) Slash pine (*Pinus elliottii*) Loblolly pine (*Pinus taeda*) Pond pine (*Pinus serotina*)	Abrahamson and Hartnett (1990), U.S. Army Corps of Engineers (1988).	Palustrine (Freshwater) Forested
Shrub Wetlands				
Dwarf or Scrub Cypress	Dwarf or scrub cypress wetlands are found on frequently flooded rock or marl soils in south Florida. The largest concentration of these wetlands is in the Big Cypress region in the southwestern part of the State. These wetlands have low densities of stunted pond cypress with sparse understories.	Pond cypress (*Taxodium asendens*)	Duever et al. 1986, Ewel (1990), Ward (1943).	Palustrine (Freshwater) Shrub
Shrub Swamp	Florida's shrub wetlands are characterized by dense shrubbery in areas where the water table is close to the surface and standing water pockets are common. They often border pine flatwoods, cypress or blackgum swamp forests.	Titi (*Cyrilla racemiflora*) Black titi (*Cliftonia monophylla*) Swamp haw (*Viburnum nudum*) Swamp honeysuckle (*Rhododendron viscosum*) Buttonbush (*Cephalanthus occidentalis*) Sweet pepperbush (*Clethra alnifolia*) Willows (*Salix spp.*) Stiff Cornel (*Cornus foemina*) Alder (*Alnus serrulata*)	U.S. Army Corps of Engineers (1988), Wolfe *et al.* (1988).	Palustrine (Freshwater) Shrub
Shrub Bogs	There are a small number of bogs in Florida that are found around lakeshores, in dome swamps and in sink holes (generally north of Highlands County). Shrub bogs occur on peat substrate that is continually saturated. Characteristic vegetation is composed of sphagnum moss and dense evergreen shrub thickets.	Sphagnum moss (*Sphagnum spp.*) Black titi (*Cliftonia monophylla*) Pond pine (*Pinus serotina*) White cedar (*Chamaecyparis thyoides*) Buttonbush (*Cephalanthus occidentalis*) Sundew (*Drosera capillaris*) Pitcher plant (*Sarracenia minor*)	Florida Natural Areas Inventory and Florida Dept. of Nat. Resources (1990), U.S. Army Corps of Engineers (1988), Wolfe *et al.* (1988).	Palustrine (Freshwater) Shrub
Freshwater Marsh				
Long Hydroperiod	Deep marsh—may contain more than 110 species of hydrophytic plants.	White water lily (*Nymphaea ordorata*) Neverwet (*Orontium aquaticun*) Yellow lotus (*Nelumbo lutea*) Naiad (*Najas guadalupensis*) Bladderwort (*Utricularia spp.*) Pondweed (*Potamogeton spp.*)	Gunderson (1994), Hart and Newman (1995), Kushlan (1990).	Palustrine (Freshwater) Emergent
Moderate Hydroperiod	Shallow marsh—may contain more than 175 species of hydrophytic plants.	Cattail (*Typha spp.*) Bullrush (*Scirpus spp.*) Pickerelweed (*Pontederia lanceolata*) Arrowhead (*Sagittaria latifolia*) Spikerush (*Eleocharis spp.*) Maidencane (*Panicum hemitomon*) Fire flag (*Thalia geniculata*) Tracy's beakrush (*Rynchospora tracyi*)		

Table 2. Wetland habitat descriptions, characteristic plant species and classification designation(s) as found in this study—Continued.

Habitat—Community Type and Synonyms	*Description*	*Characteristic Plant Species*	*References*	*Designation for This Study*
		Coastal Flats and Rolling Plain—Continued		
Short Hydroperiod	Includes swales and wet prairies, which occur in low areas throughout Florida. These wetlands are often dry for part of the year. Some wet prairies in Florida support over 320 species of herbaceous and woody hydrophytes.	Maidencane (*Panicum hemitomon*) Saw grass (*Cladium jamaicensis*) Muhly (*Muhlenbergia fillipes*) Cordgrass (*Spartina bakeri*) White-topped sedge (*Dichromena colorata*) St. John's- wort (*Hypericum fasciculatum*) Spikerush (*Eleocharis cellulosa*)		
Freshwater Pond	Many manmade ponds in Florida have been created for water retention, aesthetic purposes, or agricultural use. These open water ponds may be maintained or periodically treated to be free of vegetation. Other areas such as borrow pits or excavations have filled with water over time and may be fairly deep or lack nutrients to support aquatic vegetation. Other ponds throughout the State support submerged, floating or emergent wetland vegetation. These wetlands are characteristically small (less than 20 acres or 8 ha) and hold shallow water during years of normal precipitation.	Pickerel weed (*Pontederia lanceolata*) Arrowhead (*Sagittaria latifolia*) Rushes (*Juncus spp.*) Duck weeds (*Lemna spp.*) Spatterdock (*Nuphar luteum*) Water lily (*Nymphaea odorata*) Water shield (*Brasenia schreberi*) Bladderworts (*Utricularia spp.*)	Hart and Newman (1995), U.S. Army Corps of Engineers (1988).	Palustrine (Freshwater) Unconsolidated Bottom (Ponds)
Springs	Florida has numerous freshwater springs which originate from artesian openings in the underground aquifer. Springs are usually clear and have sand bottoms or exposed limestone along a central channel. Many of the larger springs are used extensively for recreation particularly fishing, snorkeling, tubing, canoeing and swimming.	Southern Naiad (*Najas guadalupensis*) Tape grass (*Vallisneria americana*) Eelgrass (*Sagittaria latifolia*) Pond weed (*Zannichellia palustris*) Muskgrass (*Chara spp.*) Wild Rice (*Zizania aquatica*)	Florida Natural Areas Inventory and Florida Dept. of Nat. Resources (1990), Nordlie (1990).	Palustrine (Freshwater) Unconsolidated Bottom or Palustrine Emergent

A canal in the Everglades.

Rookery Bay National Estuarine Research Reserve.

Results: Status, Distribution and Trends

This study estimated that in 1996 there were 11.4 million acres (4.6 million ha) of wetlands in Florida. Wetlands occupied approximately 29 percent of the area of the State, a greater percentage of the land surface than any other state in the conterminous United States (Dahl 1990). The bulk (90 percent) of Florida's wetlands by area were freshwater systems. The remaining 10 percent were marine or estuarine intertidal wetlands. About 56 percent of the original wetland area of Florida remained in 1996 (Figure 12). Wetland data for Florida from 1985 to 1996 are presented in Appendix B, and are summarized in Table 3.

The estimated average annual rate of wetland loss was 5,000 acres (2,030 ha) between 1985 and 1996. This was an 81 percent decline in the annual rate of loss as reported for the 1970s to 1980s (Figure 13). Between 1985 and 1996, estimated wetland losses in Florida made up about 12 percent of the total National wetland loss.

Results from this study indicated that 11.5 percent of Florida's wetlands were located within the coastal zone physiographic region. The majority of wetlands, by area, were within the Gulf-Atlantic Coastal Flats (82.7 percent) and smaller percentage (5.8 percent)

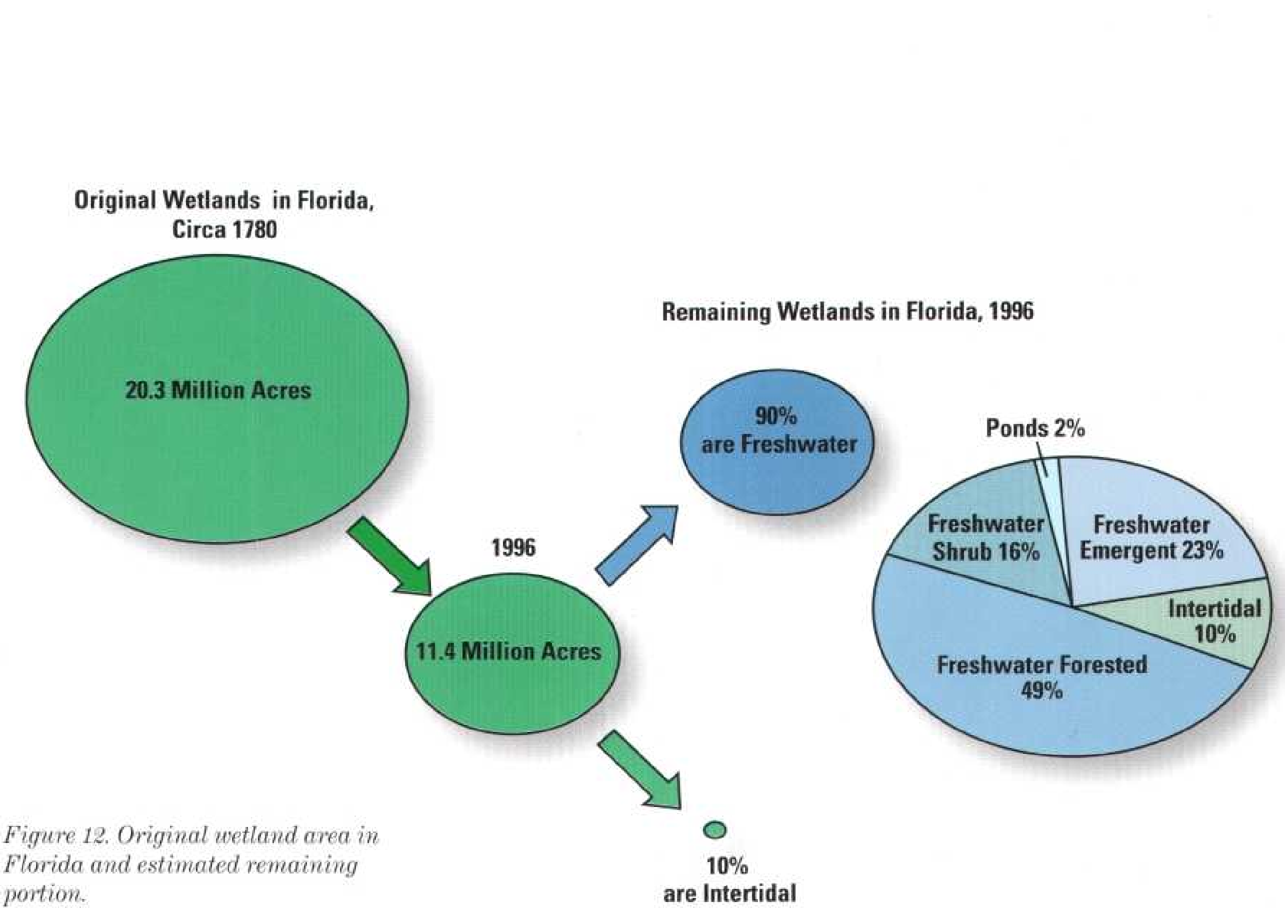


Figure 12. Original wetland area in Florida and estimated remaining portion.

were located in the Rolling Plain physiographic region (Table 4).

Urban and rural development accounted for an estimated 72 percent of the total estimated loss. Agriculture was attributed with the remaining 28 percent of the losses (Figure 14). Small gains in wetland were attributed to upland forest plantations, the "other" uplands category and from deepwater.

Florida also had an estimated 4.3 million acres (1.8 million ha) of deepwater lakes.

Pond created by mineral extraction.

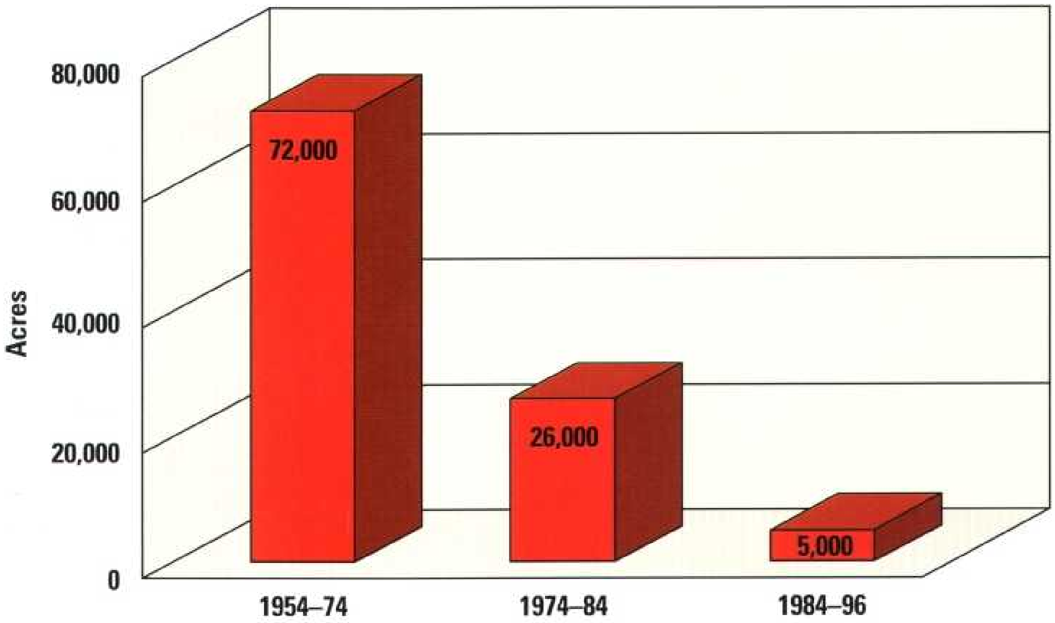


Figure 13. Average annual net wetland loss in Florida (Sources: Hefner 1986, Frayer and Hefner 1991, this study).

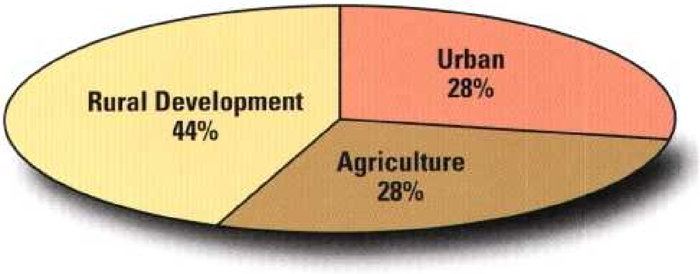


Figure 14. Net loss of wetlands to uplands, 1985 to 1996.

Table 3. Change in wetland area for selected wetland and deepwater categories, 1985 to 1996. The coefficient of variation (CV) for each entry (expressed as a percentage) is given in parentheses.

	Area, in Thousands of Acres			
Wetland/Deepwater Category	*Estimated Area, 1985*	*Estimated Area, 1996*	*Change, 1985–96*	*Change (in Percent)*
Intertidal Habitats				
Marine Intertidal	27.5 (38.1)	26.5 (38.3)	-1.0 (*)	-3.6
Estuarine Intertidal Nonvegetated[1]	183.4 (20.8)	179.8 (20.8)	-3.5 (*)	-1.9
Estuarine Intertidal Vegetated[2]	926.7 (10.7)	930.7 (10.7)	4.0 (63.1)	0.4
All Intertidal Wetlands	1,137.6 (9.3)	1,137.1 (9.3)	-0.5 (73.0)	<-0.1
Freshwater Habitats				
Freshwater Nonvegetated[3]	201.4 (7.7)	240.6 (7.4)	39.2 (24.3)	19.5
Freshwater Vegetated[4]	10,085.5 (3.9)	9,994.2 (3.9)	-91.3 (46)	-0.9
Freshwater Emergent	2.897.1 (9.6)	2,636.9 (9.9)	-260.2 (26.7)	-9.0
Freshwater Forested	5,543.7 (4.8)	5,566.2 (5.0)	2.5 (*)	-2.3
Freshwater Shrub	1,644.7 (9.3)	1,791.1 (8.7)	146.4 (80.8)	6.6
All Freshwater Wetlands	10,085.5 (3.8)	10,234.8 (3.8)	-52.1 (80.2)	-0.5
All Wetlands	11,424.5 (3.6)	11,371.9 (3.5)	-52.6 (79.7)	-0.5
Deepwater Habitats				
Lacustrine[5]	1,696.2 (16.6)	1,676.4 (16.7)	-19.8 (*)	-1.2
Riverine	135.3 (32.5)	136.7 (32.3)	1.4 (60.6)	1.0
Estuarine Subtidal	2,504.7 (5.4)	2,530.1 (5.3)	25.4 (94.9)	1.0
All Deepwater Habitats	4,336.2 (7.2)	4,343.2 (7.1)	7.0 (*)	0.2
All Wetlands and Deepwater Habitats[1,2]	**15,760 (2.7)**	**15,715.1 (2.7)**	**-45.6 (*)**	**-0.3**

* *Statistically unreliable*

[1] *Includes the categories: Estuarine Intertidal Unconsolidated Shore.*

[2] *Includes the categories: Estuarine Intertidal Emergent and Estuarine Intertidal Shrub.*

[3] *Includes the categories: Palustrine Aquatic Bed, Palustrine Unconsolidated Bottom and Palustrine Unconsolidated Shore.*

[4] *Includes the categories: Palustrine Emergent, Palustrine Forested and Palustrine Shrub.*

Table 4. Estimated acreage of wetlands within the physiographic regions of Florida, 1996.

Wetland Category	*1996 Area* Acres	Hectares	*Percent CV*
Coastal Zone			
Freshwater Wetlands			
Freshwater forested	73,430	29,717	26.3
Freshwater shrub	42,742	17,298	21.9
Freshwater emergent	57,827	23,402	37.1
Freshwater unconsolidated shore	69	28	67.1
Freshwater unconsolidated bottom	14,224	5,756	17.6
Freshwater aquatic bed	608	246	58.4
Total Freshwater wetland area for region	188,900	76,447	19.4
Intertidal Wetlands			
Estuarine intertidal shrub	614,930	248,859	13.7
Estuarine intertidal emergent	291,466	117,955	17.3
Estuarine intertidal unconsolidated shore	179,674	72,713	20.8
Total Estuarine wetland area for region	1,086,070	439,527	9.6
Marine intertidal	28,855	10,463	39.1
Total Marine wetland area for region	25,855	10,463	39.1
Total wetland area for region	1,300,825	526,437	8.3
Gulf-Atlantic Coastal Flats			
Freshwater Wetlands			
Freshwater forested	4,975,550	2,013,577	5.5
Freshwater shrub	1,682,972	681,090	9.2
Freshwater emergent	2,524,909	1,021,817	10.3
Freshwater unconsolidated shore	8,356	3,382	31.0
Freshwater unconsolidated bottom	174,100	70,457	9.0
Freshwater aquatic bed	15,659	6,337	21.2
Total Freshwater area for region	9,381,546	3,796,660	4.1
Intertidal Wetlands			
Estuarine intertidal shrub	1,378	558	55.0
Estuarine intertidal emergent	22,933	9,281	79.0
Estuarine intertidal unconsolidated shore	245	99	59.6
Total Estuarine wetland area for region	24,556	9,938	75.5
Marine intertidal	606	245	98.2
Total Marine wetland area for region	606	245	98.2
Total wetland area for region	9,406,708	3,806,843	4.1
Gulf-Atlantic Rolling Plain			
Freshwater Wetlands			
Freshwater forested	517,266	209,335	10.2
Freshwater shrub	65,411	26,472	21.8
Freshwater emergent	54,176	21,925	25.8
Freshwater unconsolidated shore	579	234	54.7
Freshwater unconsolidated bottom	23,026	9,318	15.4
Freshwater aquatic bed	3,986	1,613	31.1
Total Freshwater area for region	664,444	268,897	9.6
Total wetland area for region	664,444	268,897	9.6

Intertidal Marine and Estuarine Wetlands

Status and Distribution:

This study estimated there were slightly more than 1.1 million acres (460,300 ha) of marine and estuarine wetlands, comprising 10 percent of the area of all wetlands in Florida. This included an estimated 314,400 acres (127,290 ha) of estuarine emergent or saltmarsh wetlands, 616,300 acres (249,510 ha) of estuarine shrubs and 206,400 acres (83,560 ha) of estuarine and marine nonvegetated wetlands. Nonvegetated wetlands were commonly referred to as shores, sand or mud flats, bars and shoals.

The approximate distribution and abundance of estuarine emergent wetlands along Florida's coast line is shown in Figure 15. These saltmarsh habitats were found in embayments, estuaries and behind coastal barriers along the Atlantic seaboard and the Gulf of Mexico. Saltmarsh vegetation was sparse or absent along the shorelines of Sarasota County, the Florida Keys and the highly urbanized areas of Palm Beach, Broward and northern Dade counties. Saltmarshes were more extensive in the "Big Bend" region of Apalachicola Bay and along the coastal inlets of Nassau and Duval counties in the northeast portion of the State.

In 1996, there were an estimated 616,300 acres (249,400 ha) of estuarine shrub wetlands in Florida. The estuarine shrubs were comprised of halophytic trees and shrubs growing in brackish or saline tidal waters. This category was dominated by species of mangroves (*Rhizophora mangle, Avicennia germinans and Laguncularia racemosa*).[2] Mangroves represented subtropical or tropical intertidal

[2]This study did not differentiate distribution or extent at the species level.

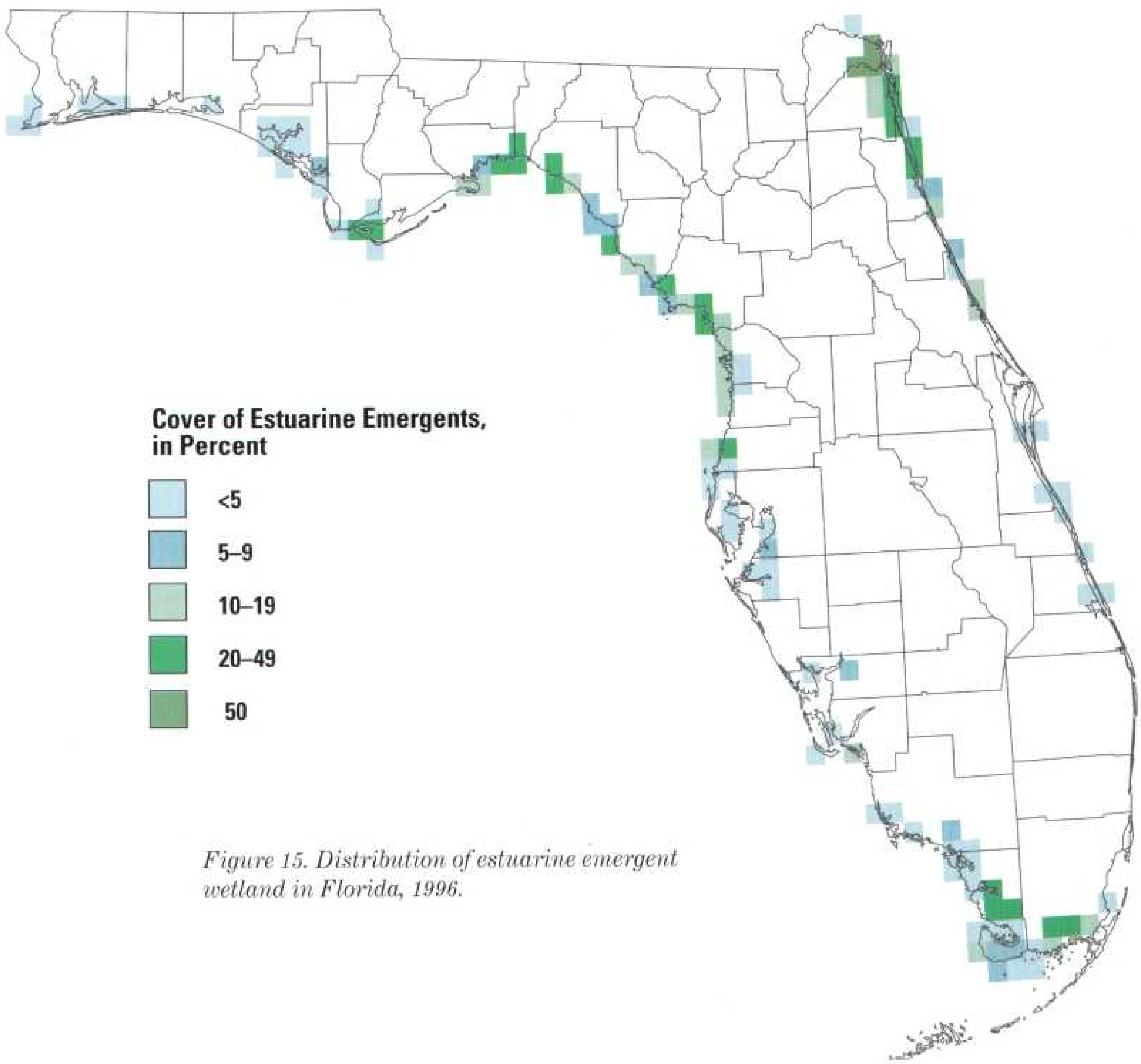


Figure 15. Distribution of estuarine emergent wetland in Florida, 1996.

communities that tolerated very little or no frost (Tomlinson 1986). They were most common in the subtropical portions of the State particularly south of Charolette Harbor, in the Ten Thousand Islands area and along Florida Bay (Figure 16). Less dense stands of estuarine shrubs were found in Biscayne Bay, the Indian River Lagoon, Tampa Bay, Ponce de Leon Inlet and Homosassa Bay. The occurrence of estuarine shrubs was observed extending as far north as the St. Mary's River Inlet and Apalachee Bay, however, these areas may have contained salt tolerant shrub species other than mangroves.

Almost all (97.8 percent) estuarine wetlands were located in the Coastal Zone. However, some estuarine emergent, shrub and nonvegetated wetlands extended into the Coastal Flats physiographic region (2.2 percent). This occurred primarily along tidal rivers and salt water canal systems.

Florida's coastal zone contained about 21 percent of all estuarine and marine wetlands and 92 percent of the estuarine shrub wetlands found in the conterminous United States. Whereas, only 8 percent of all estuarine emergent (salt marsh) wetlands were found along the State's coast lines (Table 5). An estimated 31 percent of all nonvegetated estuarine and marine habitats within the conterminous United States were found in Florida.

The mean size of emergent salt marsh wetlands and estuarine shrub wetlands within the sample sites were slightly less than 23 acres (9 ha). The estuarine nonvegetated wetlands sampled averaged just over 10 acres (4 ha) (Table 6).

Although much of Florida's population lives along or close to the coastline, less than 10 percent of the marine and estuarine wetlands sampled were located within or adjacent to urban areas (Figure 17).

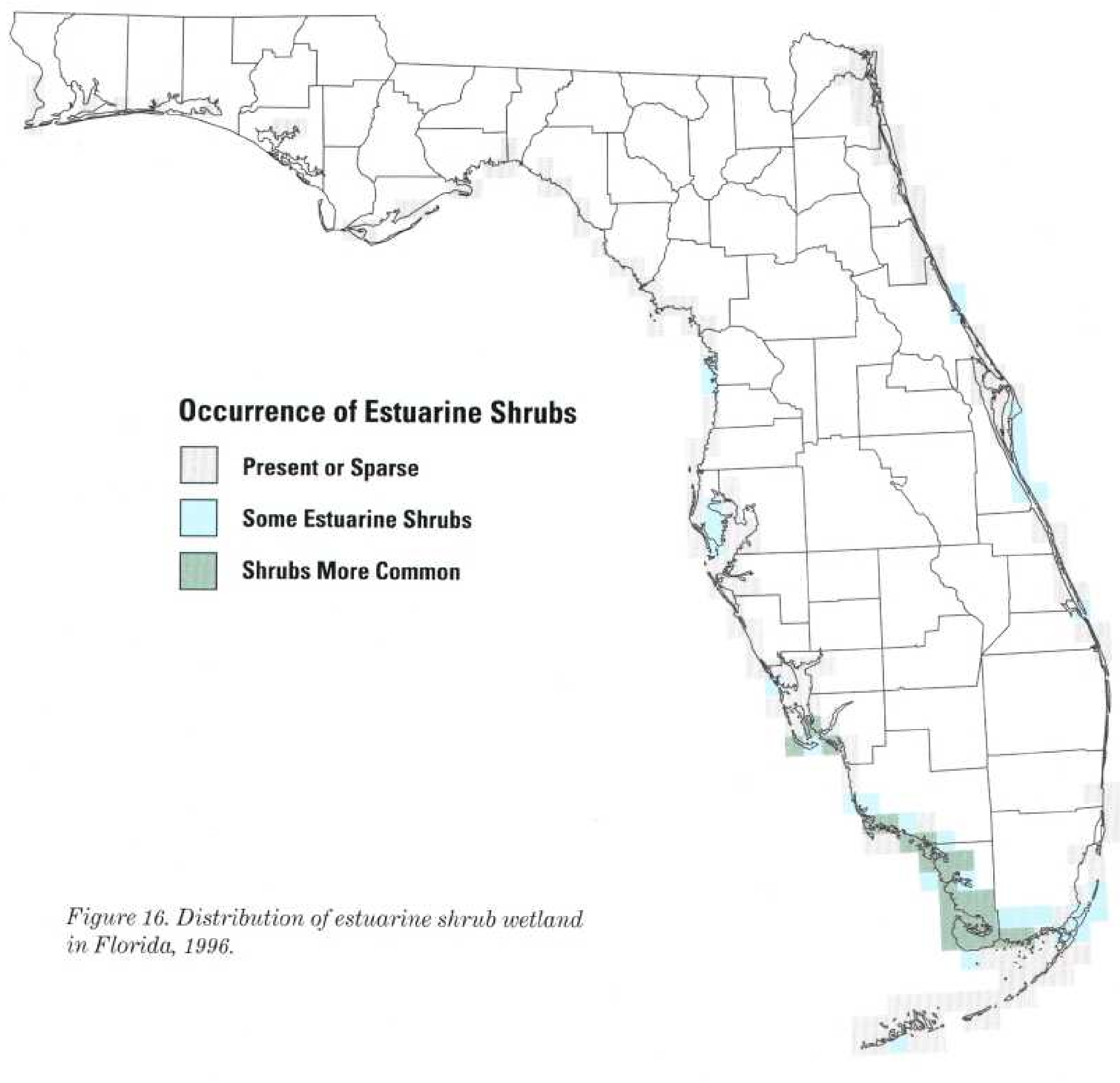


Figure 16. Distribution of estuarine shrub wetland in Florida, 1996.

Table 5. Comparison of marine and estuarine wetland area for Florida and the conterminous United States. (Sources: Dahl 2000; this study.)

	Contermimous U.S. 1986–97 (Thousands of Acres)				
Wetland Category	*1997 Area*	*Trend (in Percent)*	*Florida Area 1996 (in Acres)*	*Florida Trend (in Percent)*	*Florida Area as Percentage of National Totals*
Marine Intertidal	130.9	–2.2	26.5	–3.6	20.2
Estuarine Nonvegetated	580.1	–0.3	179.9	–1.9	31.0
Estuarine Emergent	3,942.4	–14.5	314.4	–0.6	8.0
Estuarine Shrub	672.8	+6.6	616.3	+1.0	91.6

Table 6. Mean area and size range of individual estuarine wetlands within sample units in Florida, 1996.

Wetland Category	*Mean Acres (Hectares)*	*Range, in Acres (Hectares)*
Estuarine Shrub	22.8 (9.2)	.02 to 2,500 (.008 to 1,013)
Estuarine Emergent	22.9 (9.3)	.02 to 1,225 (.008 to 508)
Estuarine Flats/Bars	10.1 (4.0)	.05 to 1,021 (.02 to 414)

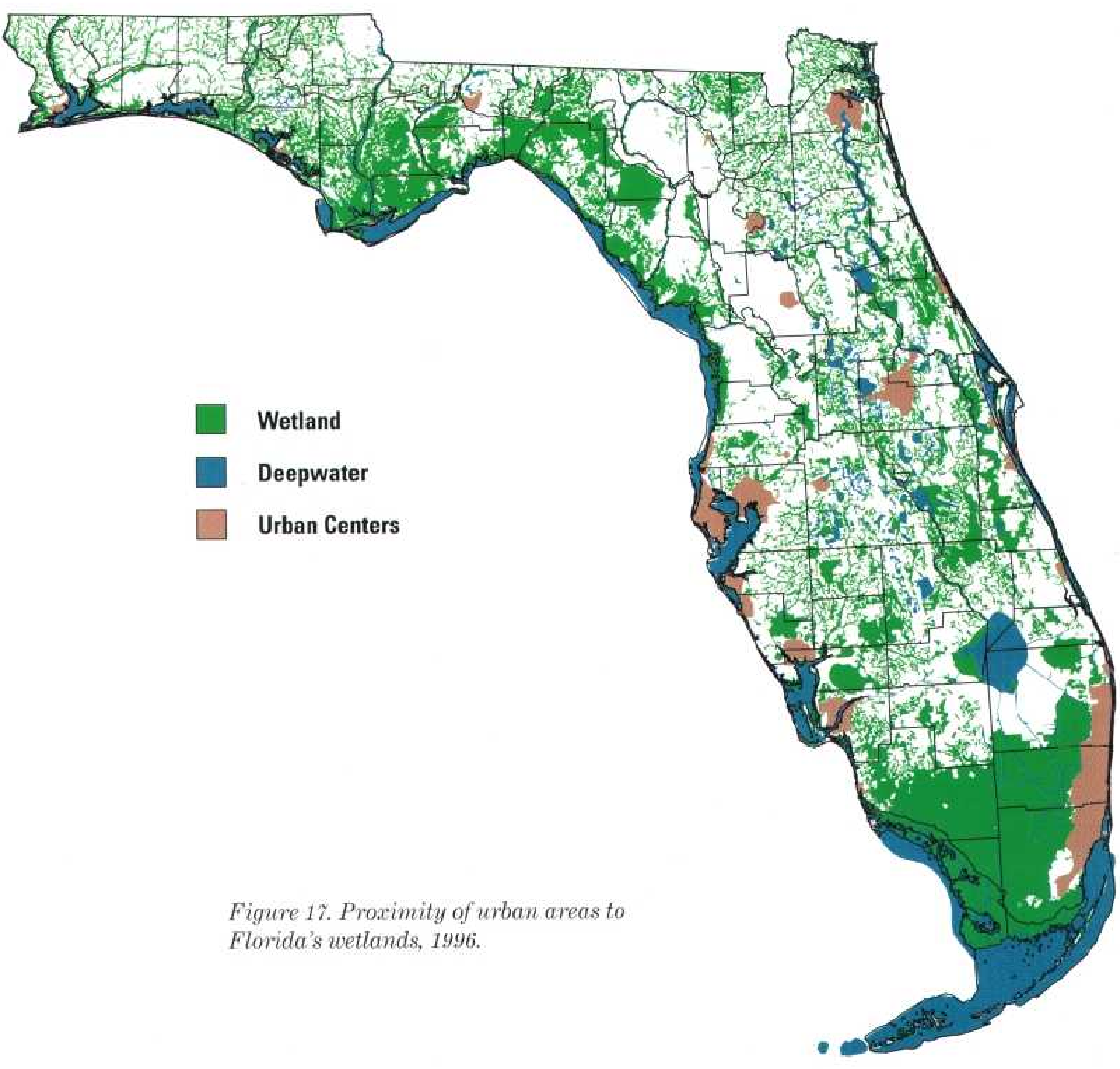


Figure 17. Proximity of urban areas to Florida's wetlands, 1996.

Trends from 1985 to 1996

Marine and estuarine nonvegetated wetlands declined by an estimated 4,500 acres (1,820 ha) between 1985 and 1996. Most of these losses were believed to have been the result of coastal erosion and storms.

Estuarine vegetated wetlands, which combined estuarine emergents and shrubs, increased slightly during this study period. Although estuarine emergents declined in area by about 1,800 acres (730 ha), this was overshadowed by increases in estuarine shrub wetlands yielding a net gain for the estuarine vegetated category as seen in Table 7. Estuarine shrubs increased by an estimated 5,800 acres (2,350 ha). Overall, intertidal estuarine vegetated wetlands increased by approximately 4,000 acres (1,620 ha) between 1985 and 1996.

Intertidal nonvegetated losses were ameliorated by the estuarine vegetated wetland gains. Florida's intertidal wetlands sustained a net loss of 500 acres (200 ha) or less than 1 percent during this study period. Frayer and Hefner (1991) reported a net decline of 2,900 acres (1,170 ha) to all marine and estuarine wetlands from the 1970s and 1980s. Compared with the results of this study there was an 83 percent decline in the loss rate of marine and estuarine wetlands.

Long-term trends in intertidal wetland types are shown in Figure 18.

Attribution of Losses and Conversions —Marine and Estuarine Wetlands

The area of marine and estuarine wetland lost to uplands is shown in Table 8. The loss of 17 acres (7 ha) of estuarine emergent wetland to upland was statistically insignificant. Seventy-five percent of the estuarine shrub losses were attributable to some form of coastal development. This may have involved construction of bridges, roadways, urban or suburban development or infrastructure. Twenty percent of the estuarine shrub losses were attributed to agriculture and 5 percent were due to other unidentified upland land uses.

Seventy-one percent of the losses to estuarine shores were attributed to urban expansion along the coast. The remaining 29 percent of the loss to upland from this category was due to expansion of other unidentified types of upland land use.

The conversion of marine and estuarine wetlands to deepwater habitats involved losses to open water bay bottoms (deep water estuaries), or open ocean.

Table 7. Changes in estuarine and marine intertidal wetlands, 1985 to 1996. The coefficient of variation (CV) for each entry (expressed as a percentage) is given in parentheses.

	Area in Thousands of Acres			
Wetland Category	*Estimated Area, 1985,*	*Estimated Area, 1996*	*Gain or Loss, 1985–96*	*Area (as Percentage) of All Intertidal Wetland, 1996*
Nonvegetated				
Marine Intertidal	27.5 (38.1)	26.5 (38.3)	-1.0 (*)	2.3
Estuarine Intertidal Nonvegetated	183.4 20.8	179.9 20.8)	-3.5 (*)	15.8
Vegetated				
Estuarine Emergent	316.2 (17.2)	314.4 (17.0)	-1.8 (*)	27.7
Estuarine Shrub	610.5 (13.7)	616.3 (13.7)	5.8 (83.8)	54.2
Estuarine Intertidal Vegetated1	926.7 (10.7)	930.8 (10.7)	4.0 (63.1)	81.9
Net Intertidal Change	**1,137.6**	**1,137.1**	**-0.5**	**100**

**Statistically unreliable*

[1]Includes the category: Estuarine Unconsolidated Shore.

[2]Includes the categories: Estuarine Emergent and Estuarine Shrub.

Table 8. Changes in marine and estuarine intertidal wetlands, 1985–96.

			Acres		
Wetland Category	*Percentage of All Intertidal Wetland in Florida, 1996*	*Change, 1985–96, in Percent*	*Area Lost to Upland*	*Area Converted to Deepwater*	*Change as Percentage of Intertidal Gross Change*
Marine Intertidal	2.3	-4.0	0	657	6.5
Estuarine Nonvegetated	15.8	-1.9	249	6,561	67.8
Estuarine Emergent	27.7	-0.6	17	290	3.1
Estuarine Shrub	54.2	1.0	2,185	90	22.6
Gross Change to Intertidal Wetlands			2,451	7,598	100

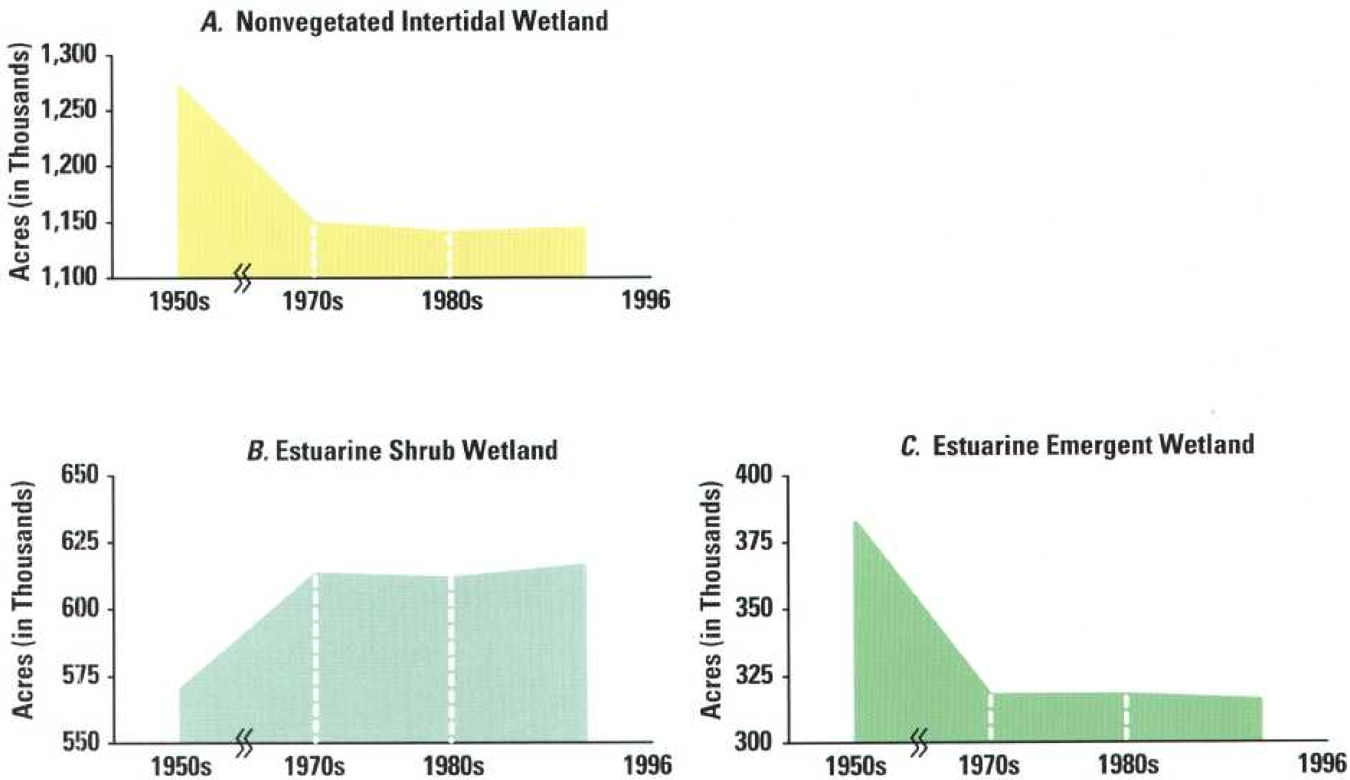


Figure 18. Long term trends of intertidal wetland types in Florida, 1950s to 1996.

Freshwater Wetlands

Status and Distribution

In 1996, there were an estimated 10.2 million acres (4.1 million ha) of freshwater (palustrine) wetlands that comprised 90 percent of all wetland area in the State. An estimated 98 percent were vegetated the remaining 2 percent were open water ponds. Nationwide, Florida had an estimated 10.2 percent of all freshwater wetlands in the conterminous United States.

Of these freshwater wetlands, there were an estimated 5.6 million acres (2.3 million ha) of forested wetlands, 1.8 million acres (725,000 ha) of shrubs, 2.6 million acres (1.1 million ha) of emergent wetlands or marshes and 241,000 acres (98,000 ha) of freshwater ponds. Almost 92 percent of these wetlands were located in the Coastal Flats physiographic region of the State.

Freshwater forested wetlands were distributed throughout the State excluding much of the Everglades and the Florida Keys. Forested wetlands were sparse in Pinellas, Marion, Suwanee, Hendry, Glades and Okeechobee counties. Forested wetlands were most dense in the Fakahatchee Strand and Big Cypress Preserve areas of Collier County, and the Big Bend counties of Levy, Dixie, Taylor, Jefferson, Wakulla, Franklin and Gulf. Bottomlands adjacent to river and stream systems and the wet pine flatwood areas of the Florida Panhandle also contained moderate numbers of forested wetlands. Pockets of forested swamps also occurred in Volusia County east of Lake George, the Green Swamp area of Polk County and around Blue Cypress Lake in Indian River County.

Freshwater emergent wetland distribution was concentrated in what was the historic Everglades ecosystem, extending from Lake Okeechobee through the Everglades National Park including the western margins of St. Lucie and Martin Counties. Emergent marshes and wet prairies were also prevalent in DeSoto and Charlotte Counties. The Kissimmee River system in Okeechobee and Osceola Counties as well as the St. John's River system in Volusia, Brevard and Indian River Counties supported considerable emergent wetlands as did Sumpter

Sawgrass Lake, Florida.

and Lake Counties in central Florida.

Few freshwater wetlands were found within the Coastal Zone physiographic region. These occurred in the interior portions of barrier islands, and where rivers flowed into coastal estuaries. Less that 2 percent of Florida's freshwater wetlands were located in this coastal stratum (Table 9).

The Coastal Flats contained most of the freshwater wetlands in Florida. Almost 90 percent of the forested wetlands, 94 percent of the freshwater shrubs and nearly 96 percent of freshwater emergent marshes were in the Coastal Flats.

A small percentage of freshwater shrubs and emergents was found in the Rolling Plain. Some forested wetlands (about 9 percent) were also found in this physiographic region.

The size of freshwater wetlands contained within the sampling of this study indicated forested wetlands had a mean size larger than shrubs or emergent wetlands (Table 10). Forested wetlands were 17.7 acres (7 ha) with emergent marshes and shrub wetlands 9.9 acres (4 ha) and 7.1 acres (3 ha) respectively. The mean size of freshwater ponds identified in this study was 1.7 acres (0.7 ha).

There was a noticeable difference in the type of freshwater wetland found within or adjacent to urban areas in Florida. About 25 percent of the forested wetlands sampled were in urban settings, whereas less than 3 percent of freshwater shrub wetlands and 5 percent of the emergent wetlands occurred in urban areas.

Trends from 1985 to 1996

Florida's freshwater wetlands declined by an estimated 52,000 acres (21,100 ha) or 0.5 percent between 1985 and 1996. This was an average annual net loss of 4,740 acres (1,920 ha). The average annual rate of freshwater wetland loss had declined 82 percent since the 1970s to the 1980s.

Freshwater vegetated wetlands declined by an estimated 91,000 acres (36,800 ha) or 0.9 percent. Freshwater emergent wetlands exhibited the largest losses declining by an estimated 260,000 acres (10,500 ha) or 9.0 percent (Table 11).

Table 9. Distribution of freshwater wetland types by physiographic region in Florida, 1996.

Physiographic Region	*Estimated Area in Acres (Hectares)*	*Percent CV*[1]	*Percentage of Total Freshwater Wetland*
Gulf-Atlantic Rolling Plain	66, 444 (268,897)	9.6	6
Gulf-Atlantic Coastal Flats	9,381,546 (3,796,660)	4.1	92
Coastal Zone	188,900 (76,447)	19.4	2
Total Freshwater Wetland	**10,234,890 (4,142,003**	**3.8**	**100**

[1]*Percent coefficient of variation is expressed as (standard error/mean)*100.*

Table 10. Mean area and size range of individual freshwater wetlands within sample units in Florida, 1996.

Wetland Category	*Mean Acres (Hectares)*	*Range in Acres (Hectares)*
Freshwater Forested	17.7 (7.2)	.02 to 2,554 (.008 to 1,034)
Freshwater Shrub	7.1 (2.9)	.02 to 2,339 (.008 to 947)
Freshwater Emergent	9.9 (4.0)	.02 to 2,5571 (.008 to 1,036)
Freshwater Ponds	1.7 (0.7)	.03 to 1432 (.012 to 58)
Other Miscellaneous Freshwater Types	2.0 (0.8)	.02 to 80 (.008 to 32)

[1]*The upper size limit was restricted by sample plot size.*

[2]*The upper size limit reflected the area of ponds connected in series.*

Freshwater ponds increased in area by over 39,000 acres (15,800 ha), almost 20 percent. Forested wetland area increased slightly (0.4 percent) while shrub wetlands increased by an estimated 8.9 percent. These gains largely overshadowed the losses of freshwater emergents wetlands.

Long term trends in freshwater wetland types indicated that freshwater ponds continued to increase over time. Freshwater forested wetlands reversed a long term trend and sustained a net gain in area, while emergent wetlands continued to decline (Figure 19).

Attribution of Losses and Conversions —Freshwater Wetlands

Net losses of freshwater wetland between 1985 and 1996 were attributed to rural development, urban development and agriculture (Figure 20). Small net gains were recorded from silviculture and the "other uplands" land use categories.

Loss of wetlands to urban and rural development involved drainage for homes, resorts, golf courses, industry, roads, bridges and other infrastructure. Urban and rural development activities accounted for an estimated 72 percent of the net wetland losses.

Agriculture accounted for an estimated 28 percent loss of freshwater wetlands. Primarily in south Florida, where emergent wetlands were converted to citrus production, horticulture, growing landscape or other ornamental plants, greenhouses, sod farms and other uses. The net losses attributed to agriculture declined by 79 percent compared to the estimated losses attributed to agriculture during the 1970s to 1980s.

Freshwater Lakes and Reservoirs

About 49,000 acres (19,800 ha) of freshwater lakes were created from uplands between 1985 and 1996. Despite these gains, lacustrine deepwater areas experienced a net decline of 19,700 acres (8,000 ha), or 1.2 percent. The loss of deepwater habitats to freshwater wetlands helped offset wetland losses to upland land uses.

Table 11. Changes in freshwater wetlands, 1985 to 1996. The coefficient of variation (CV) for each entry (expressed as a percentage) is given in parentheses.

	Area in Thousands of Acres			
Wetland Category	*Estimated Area, 1985*	*Estimated Area, 1996*	*Change, 1985–96*	*Change (in Percent)*
Freshwater Vegetated Wetlands				
Freshwater Forested	5,543.7 (4.8)	5,566.2 (5.0)	22.5 (*)	0.4
Freshwater Shrub	1,644.76 (9.3)	1,791.1 (8.7)	146.5 (80.8)	8.9
Freshwater Emergent	2,897.1 (9.6)	2,636.9 (9.9)	–260.3 (26.7)	–9.0
All Freshwater Vegetated Wetlands	10,085.5 (3.9)	9,994.2 (3.9)	–91.3 (46)	–0.9
Freshwater Nonvegetated Wetlands				
Ponds[1]	195.1 (7.9)	231.6 (7.5)	36.5 (25.1)	18.7
Miscellaneous Types	6.3 (19.6)	9.0 (28.9)	2.7 (86.2)	42.9
All Freshwater Nonvegetated Wetlands	201.4 (7.7)	240.6 (7.4)	39.2 (24.3)	19.5
All Freshwater Wetlands	**10,286.9 (3.8)**	**10,234.8 (3.8)**	**–52.1 (80.2)**	**–0.5**

**Statistically unreliable.*

[1]Includes the categories: Freshwater Aquatic Bed and Freshwater Unconsolidated Bottom

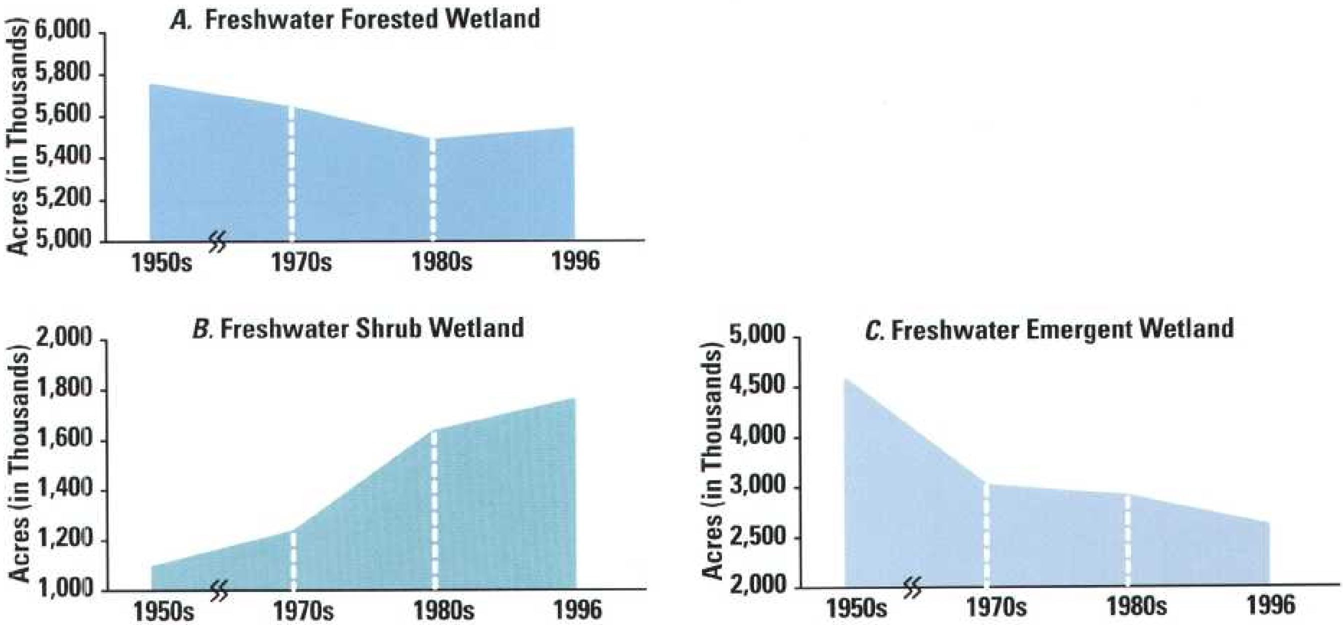


Figure 19. Long term trends of freshwater wetland types in Florida, 1950s to 1996.

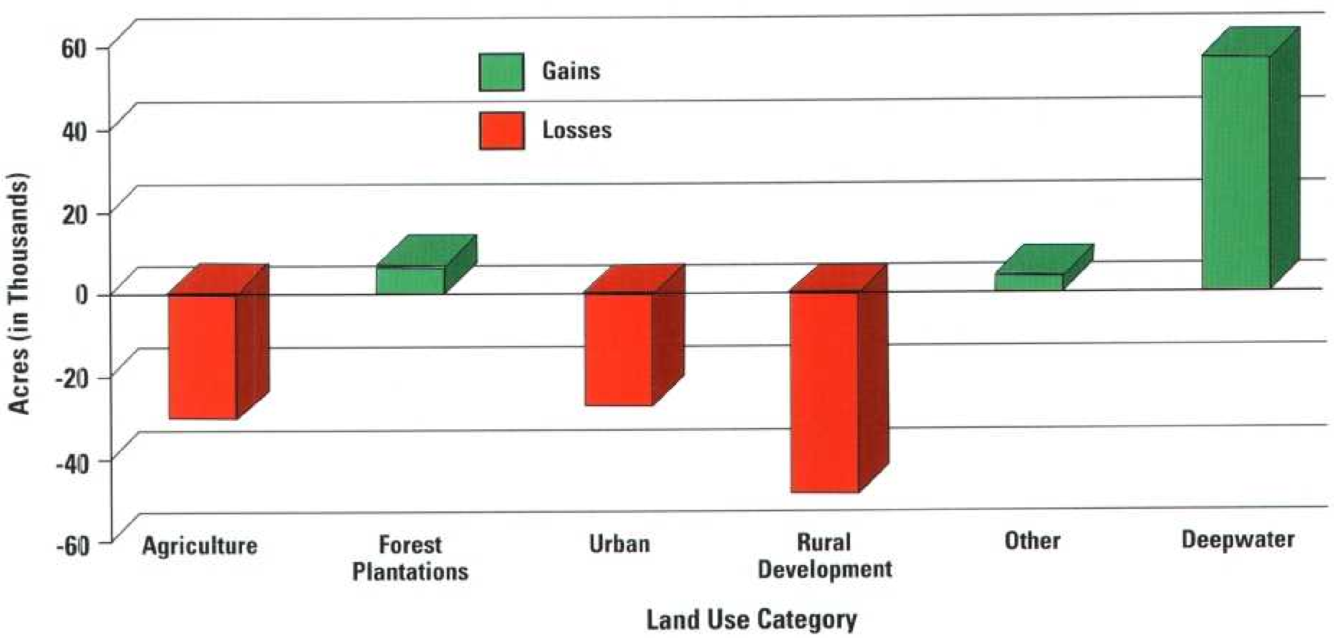


Figure 20. Net losses and gains of wetlands to various land use types, 1985 to 1996.

Intertidal Marine and Estuarine Wetlands

Three major categories of estuarine and marine wetlands were included in this study: estuarine intertidal emergents (salt and brackish water marshes), estuarine shrubs (mangrove swamps or mangles and other salt tolerant woody species), and estuarine and marine intertidal nonvegetated wetlands. This later category included exposed coastal beaches subject to tidal flooding, as well as sand bars, tidal mud flats, shoals, and sand spits.

In 1996, Florida had an estimated 1.1 million acres (460,300 ha) of marine and estuarine wetlands. Twenty-one percent of all intertidal wetlands in the conterminous United States were found in Florida. While only 8 percent of the estuarine salt marsh vegetation in the lower 48 States was found along Florida's coastline, the State harbored over 91 percent of the estuarine shrub habitat of the Nation.

Less than 1 percent of Florida's wetland losses between 1985 and 1996 were intertidal wetlands. During previous eras, development along the Gulf and Atlantic coast was probably at the expense of wetlands and open land (Lynch *et al.* 1976; Lins 1980). Because

Figure 21. Jupiter Inlet, Florida, 1997. (Photo courtesy of NOAA).

Figure 22. Lauderdale by the Sea. (Photo courtesy of NOAA.)

intertidal wetlands often occupy prime scenic locations immediately along the coastline, in the past, many were developed for residential and resort communities (Figure 21). Other studies have indicated that as of 1995, over 60 percent of Floridians lived within 5 miles of the coast (Florida Coastal Management Program 1999a). However, since then, most of Florida's shoreline habitats have been protected either by regulation or through public ownership. These mechanisms in combination with continued outreach and educational efforts have been responsible for reducing intertidal wetland losses between 1986 and 1997.

Although the net loss of marine and estuarine wetland was small, in the estuarine environment there were important changes. An estimated three times as much estuarine wetland was converted to deepwater than was lost to upland. The conversion to deepwater primarily affected nonvegetated intertidal wetlands as a result of scouring, sediment movement, or shifts of sand or mud substrates resulting from dredging, coastal storms, wave action, or water currents.

Nonvegetated Marine and Estuarine Wetlands

Nonvegetated intertidal wetlands included sand and mud flats, beaches flooded by the tides at regular intervals and shallow water features such as sand bars and shoals. It was estimated that there were more than 206,000 acres (83,600 ha) of marine and estuarine nonvegetated wetlands in 1996 than there were in 1985.

Intertidal flats were nonvegetated (or sparsely vegetated) saline areas that were inundated during high tides or storms. These flats were usually composed of sand or mud and were found scattered along Florida's coastline. When flooded with shallow water, sand flats provided habitat for sport fish such as the sand sea trout (*Cynoscion arenarius*), bonefish (*Albuta vulpes*), tarpon (*Magalops atlanticus*), snook (*Centropomus undecimalis*), and red drum (*Sciaenops ocellatus*). Exposed flats of sand or mud provided habitat for many organisms important to intertidal food web such as polychaete worms, crustaceans, mollusks and amphipods (Livingston 1990).

Florida's sand beaches have provided considerable recreational, commercial and aesthetic benefits to people (Figure 22). This wetland type has also been important to unique wildlife species. For example, the green sea turtle (*Chelonia mydas*) and the loggerhead sea turtle (*Caretta caretta*) use sandy beaches for nesting sites. The highest nest densities of loggerhead turtles have been found in southern Broward County from Cape Canaveral to Sebastian Inlet (Hopkins and Richardson 1984). Florida beaches have also been important as nesting habitats for several species of shore birds (Johnson and Barbour 1990).

The constant movement of sediment and water resulting from tidal influences, wave action and coastal storms, made these wetlands dynamic. The erosion and accretion of sand or mud was a continual process in response to the number and severity of coastal

The loggerhead sea turtle (Caretta caretta) uses sandy beaches for neting. A tracking device was attached to this turtle before it returned to the sea. (Ron Hagerty) storms, wind and wave action, and currents. Coastal storm frequency and strength may have modified the rates of sediment deposition and erosion (Williams *et al.* 1999). By scouring away sand flats or bars, or depositing sand to create or elongate sand spits and shallow water shoals, coastal storms had the potential to reconfigure long stretches of shoreline.

Dredging, placement of fill, beach renourishment or construction of shoreline armorment also has affected coastal sediments in shallow water environments. Coastal armoring including the construction of sea walls, jetties, bulkheads, stabilization of shorelines or protecting inlets may have exacerbated or relocated some of the coastal erosion processes (Bergquist 1996).

Florida had an estimated 206,400 acres (38,560 ha) of marine and estuarine nonvegetated wetland in 1996. Frayer and Hefner (1991) reported that Florida had experienced a net gain of 4,000 acres (1,620 ha) in nonvegetated intertidal wetland from the 1970s to the 1980s. Results from this study estimated a net loss of 4,500 acres (1,820 ha) of nonvegetated intertidal wetland between 1985 and 1996. This trend corresponded with data collected between 1989 and 1993 that indicated an increase in shoreline erosion of nearly 7 percent in Florida (Florida Coastal Management Program 1999a). Certain segments of Florida's coastline exhibited erosion and accretion of sediments between 1985 and 1996 (Figure 23). These types of intertidal wetlands have demonstrated temporal changes in the past. The long term trends indicated an overall reduction in the losses that were reported for nonvegetated intertidal wetlands from the 1950s to 1970s.

Estuarine Emergent Wetlands

Estuarine emergent (saltmarsh) vegetation occurred along low energy shorelines often behind barrier islands or within embayments and tidal river systems. Estuarine emergent marshes were typified by salt-tolerant plants periodically flooded by tidal waters (Cowardin *et al.* 1979). Researchers have found plant species vary depending on location (Carlton 1977; Duever *et al.* 1982; Montague and Wiegert 1990). Those found along the Atlantic coast in Nassau, Duval and St. Johns counties for example, were dominated by smooth cordgrass (*Spartina alterniflora*). Whereas, salt marshes along the Gulf of Mexico (Dixie, Levy and Taylor counties) were generally dominated by black needle rush

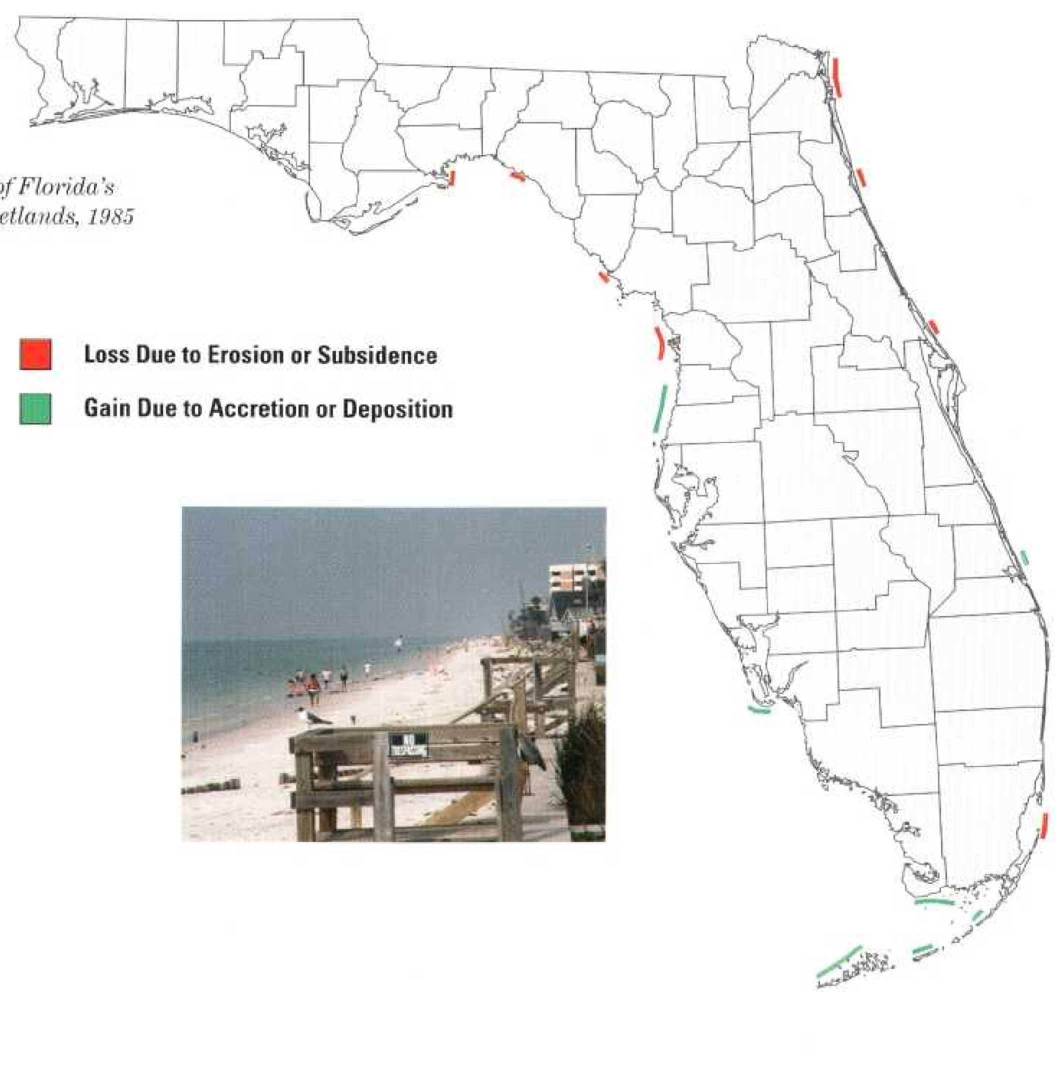


Figure 23. Loss and gain of Florida's estuarine non-vegetated wetlands, 1985 to 1996.

(*Juncus roemerianus*) as shown in Figure 24.

The ecological value of estuarine salt marsh wetlands has been well documented (Livingston 1984, Montague and Wiegert 1990). These wetlands were important as nursery areas for fishes, shellfish, crustaceans and other benthic organisms. Salt marshes also provided valuable habitat for birds and other wildlife, help transport valuable nutrients, prevent erosion and buffer the impacts of coastal storms.

Salt marsh vegetation accounted for less than one third of the estimated intertidal wetlands in Florida in 1996. There were an estimated 314,000 acres (127,290 ha). These marshes decreased by an estimated 1,800 acres (730 ha) or 0.6 percent between 1985 and 1996. This continued a downward trend that has been documented since the 1950s, albeit the rate of decline has slowed considerably. Only modest losses to upland land use (17 acres or 7 ha) and deepwater systems (290 acres or120 ha) were observed.

Estuarine salt marsh was lost to deepwater where the vegetation was scoured or buried by sediments, or was washed away by rising water or turbulent wave action. Without sufficient support around the plant base and root structures, vegetation fragmented and washed away. This occurred along the coast lines of Citrus and Hernando counties. Statewide this was only a minor cause for the decline in salt marsh, accounting for only 3 percent of estuarine salt marsh decline.

Mashes Island County Park, Wakulla County, Florida.

Modest estuarine salt marsh gains were observed in the counties of Wakulla and Taylor along the Gulf Coast and, Duval and St. John's County along the Atlantic. These gains helped offset losses of salt marsh that occurred elsewhere in the State.

The major factor in the net decline of salt marsh wetlands was the conversion to estuarine shrubs primarily along the Gulf coast in Sarasota, Charlotte, Lee, Collier, Monroe and south Dade counties.

Figure 24. Estuarine salt marsh of north Florida dominated by black needlerush (Juncus roemerianus), 1994.

Estuarine Shrub Wetlands

Figure 25. Mangroves and surrounding waters of Florida Bay, 1991.

The most notable component of the estuarine shrub category were the mangroves (Figure 25). Florida has always been the primary location of mangrove wetlands in the United States. Mangrove species are uniquely adapted to saline environments and ecologically, mangroves have supported a diversity of wildlife (Odum and McIvor 1990). Mangrove communities and surrounding waters of south Florida support more than 220 species of fish, 24 species of reptiles and amphibians, 18 mammals and 181 bird species (U.S. Fish and Wildlife Service 1996). Other values of mangrove wetlands include exporting organic matter to coastal food chains, stabilizing shorelines and protecting inland areas from hurricane damage (Mitsch and Gosselink 1993).

The geographic extent of mangroves has been influenced by cold temperatures, hurricanes, and human induced stressors (Spalding *et al.* 1997). There has been general agreement among researchers that the greatest concentrations of mangroves occurred along the southern tier of counties including Lee, Collier, Monroe and Dade (U.S. Fish and Wildlife Service 1996, Spalding et al. 1997, Wilson 1998).

Spalding *et al.* (1997) also noted that large expanses of mangroves occurred in protected areas such as Everglades National Park. Results from this study have also indicated a close relationship between mangrove wetland distribution in south Florida and Federal or State designated conservation areas (Figure 26). Conversely, only 7 percent of all estuarine shrub wetlands were associated with urban areas.

Occurrences of estuarine shrub wetlands in north Florida may have included woody species other than mangroves. Mitsch and Gosselink (1993) indicated that the northern-most extent of black mangrove (*A. geminans*) occurred at about 30 degrees N. latitude. Although scattered stands of mangrove shrubs have been found along the north coast of the Gulf of Mexico (Odum and McIvor 1990), these wetlands have been exposed to freezing temperatures that greatly reduced their number and distribution. Other salt-tolerant or invasive woody plants in these northern wetlands included false willow (*Baccharis angustifolia*), saltbush (*Baccharis halimifolia*), buttonwood (*Conocarpus erectus*), bay cedar (*Suriana maritina*) and Brazilian pepper (*Schinus terebinthifolius*).

Figure 26. Mangroves were concentrated within Federal, State and other conservation lands along Florida's Gulf Coast, 1996.

Estuarine shrub area increased in Florida from 610,500 acres (247,170 ha) to 616,300 acres (249,510 ha) between 1985 and 1996. Historically, thousands of acres of mangroves were destroyed by dredging, ditching, diking or filling wetlands along Florida's coastline (Patterson 1986; Odum and McIvor 1990). There has also been ongoing controversy over continued development of golf courses and residential housing along marginal mangrove habitats (Twilley 1998). Specific legal protection for mangrove wetlands was enacted by the State in 1985. This, in combination with mangrove restoration and conservation practices, such as restrictive removal and pruning, has helped increase the extent of mangroves in south Florida (Figure 27). This has resulted in slight increases in estuarine shrub wetland area.

A contributing factor that accounted for increased estuarine shrub area, was the invasion and establishment of exotic shrub species within and bordering estuarine wetlands. Brazilian pepper (*Schinus terebinthifolius*) for example, was capable of establishment in a broad range of hydrologic conditions including intertidal mangroves (McCann *et al.* 1996). When viewed from aerial photography, monospecific stands of this invasive species appeared within the intertidal zone. Duever *et al.* (1986) and Habeck (1995) recognized exotic shrub invasion was a continuing problem in Florida. Without qualitative or species specific information, determining the ecological impact of the increased extent of exotic shrubs observed within the estuarine shrub category was not possible. This study was designed to measure changes in wetland area by generalized life form (woody shrubs) without further assessment of species composition or wetland quality.

Although some estuarine shrub wetlands were lost to open water systems, most of the losses were attributed to upland land use. An estimated 75 percent (1,635 acres or 662 ha) of the estuarine shrub area converted to upland was due to construction activities or land development along the shoreline (Figure 28).

Figure 27. Mangrove rehabilitation project in Fort De Soto Park, Pinellas County.

Figure 28. Loss or gain of estuarine shrub habitat between 1985 and 1996.

Exotic Plant Species in Florida's Wetlands

No discussion of Florida's wetlands would be complete without some acknowledgment of the presence of harmful exotic species in the ecosystem. Because of the subtropical climate and abundance of aquatic habitats, Florida is especially susceptible to infestations of exotic aquatic and wetland plants (FL Coastal Management Program 1999b). Exotic aquatic plants such as Hydrilla (*Hydrilla verticillata*) can choke waterways, inhibit navigation and recreational activities, reduce spawning habitat for fish and degrade water supplies (McCann *et al.* 1996). Other exotic wetland plants such as *Melaleuca quinquenervia* (Cajeput) and Brazilian Pepper (*Schinus terebinthifolius*) have demonstrated a remarkable ability to invade and colonize portions of Florida's landscape. These plants often form monospecific stands that dominate natural flora (U.S. Department of Interior 1994). Several of Florida's more notorious exotic plants include the following:

Hydrilla (*Hydrilla verticillata*): This plant has become a serious aquatic weed problem in Florida's freshwater environments. Hydrilla grows rapidly in waterways and will out-compete native submerged aquatic plant communities (FL Coastal Management Program 1999b). By the early 1990s hydrilla had infested more than 40 percent of Florida's public waters and was spreading (McCann *et al.* 1996). In 1995, Florida's Invasive Aquatic Plants Inventory indicated that hydrilla was most widespread in the waters of Alachua, Brevard, Citrus, Gulf, Highlands, Leon, Okechobee, Osceola, Polk, and Seminole Counties (FL Dept. of Environmental Protection 1996b).

Hydrilla verticillata or "water thyme." (Photo courtesy of Colette Jacona, U.S. Geological Survey.)

Water hyacinth (*Eichhornia crassipes*): This floating aquatic plant is one of the most prolific plant species to inhabit Florida's lakes, rivers and canals systems. Water hyacinth blocks waterways and limits boat traffic, recreation, and wildlife use. Large expanses of this plant impede the ability of the snail kite (*Rostrhamus sociabilis*) to find important food items (Griffen 1989) and mats of water hyacinth can crowd out native aquatic plants and thus reduce biological diversity in freshwater ecosystems. The extent of water hyacinth has been reduced due to control efforts by the State and U.S. Army Corps of Engineers. In 1995, acres of water hyacinth could still be found in Okechobee, Osceola, Seminole and St. Johns counties (FL Dept. of Environmental Protection 1996b).

Water hyacinth filling a canal. (Photo courtesy of Dr. Terry McTique, NOAA)

Melaleuca (*Melaleuca quinquenervia*), Cajeput or Punk Tree: This tree species is perhaps the most insidious exotic to invade Florida's wetlands. The principal reason for its original introduction in Florida, was for drying up the Everglades (Thayer *et al.*1990). Melaleuca trees can grow up to 25 m tall and exist in soil conditions ranging from dry sand to muck covered with several feet of water (Tarver *et al.* 1988). Although there are no precise estimates of the extent of Melaleuca throughout the State, the species is prevalent throughout south Florida. Within the Everglades and Big Cypress National Preserve, it has

Melaleuca or punk tree. (Photo courtesy of the South Florida Water Management District.)

invaded the cypress-pine ecosystem and displaced areas of cypress (*Taxodium distichum*) with dense monospecific Melaleuca forest (Myers 1986). There are concerns for the long-term protection of regional water tables, increased expenditures for the treatment of allergies caused by this plant, degradation of wildlife habitat and the high costs associated with control and eradication (McCann *et al.* 1996).

Brazilian Pepper (*Schinus terebinthifolius*): Brazilian pepper is an aggressive shrub species that grows well under a range of conditions including coastal mangrove sites, along dikes, levees or ponds, hammocks, and drier pinelands (Tarver *et al.* 1988). These plants often create a dense canopy and eliminate almost all herbaceous understory (Ewel 1978). In the 1990s, it was reported that thousands of acres existed in central, and south Florida, the Florida Keys and other islands of the State (Bennett and Habeck 1991). Because of its environmental tolerance, Brazilian pepper is a threat to invade and colonize both freshwater and some estuarine wetlands in Florida.

Brazilian pepper. (U.S. Fish and Wildlife Service.)

Freshwater Wetlands

Florida's freshwater wetland resources have been tremendously important. Commercially valuable products such as hardwood timber, softwood for pulp and paper products, cypress mulch for gardening, and bottled spring water come from wetland areas. The long growing season and abundant forage supplied by wetland vegetation fringing many Florida lakes have made 8–10 pound largemouth bass (*Micropterus salmoides*) an angler's delight. Some Florida springs and their surrounding wetlands hide archeological or paleontologic discoveries of scientific significance.

Four major types of freshwater wetlands were included within this study. Three of these types were based on vegetative life form and included forested wetlands, woody shrubs and wetlands dominated by emergent or herbaceous plants. The fourth type was freshwater ponds less than 20 acres (8.0 ha).

Figure 29. Freshwater forested wetland dominated by red maple (Acer rubrum) and water oak (Quercus nigra), St. John's River, Florida.

In 1996, there were an estimated 10,234,800 acres (4,143,600 ha) of freshwater wetlands in Florida. In the conterminous United States, freshwater wetlands occupied about 5 percent of land surface (Dahl 2000). Freshwater wetlands occupied slightly over 27 percent of Florida's land area, making Florida the wettest State by area in the lower 48 United States.

This study indicated that Florida had 11 percent of all forested wetland area in the conterminous U.S.; 10 percent of the wetland shrubs and 10 percent of the wetland emergents, by area. Slightly more than 4 percent of the Nation's open water ponds occurred in the State. Freshwater wetlands sustained 99 percent of the all wetland losses in Florida between 1985 and 1996.

Between 1985 and 1996, freshwater forested and shrub wetlands and freshwater ponds had increased in area. These gains were offset by large losses of freshwater emergent wetlands. When wetland trends for the three vegetated freshwater wetland categories (emergent, shrub and forest) were combined there was an estimated net loss of over 91,000 acres (36,940 ha). Freshwater ponds (nonvegetated) increased in area by an estimated 39,200 acres (15,860 ha). The net result was that freshwater wetlands in Florida declined by and estimated 52,000 acres (21,080 ha).

Freshwater Forested Wetlands

Forested wetlands were most abundant. In 1996, there were an estimated 5,566,200 acres (2,253,500 ha). This comprised 54 percent of the total freshwater area for the State. Forested wetlands appeared in many different ecological associations and included wet pine flatwoods, mixed hardwoods, river swamps, cypress domes, and hydric hammocks (Figure 29).

Species diversity and forested wetland community types decreased as sampling progressed from the more temperate northern part of the State to south Florida. The proportion of forested wetland to emergent marsh also changed in a north to south gradient within the State. In the panhandle region, wetland forest to marsh ratios have been approximated at 10:1, whereas the ratio was 3:1 in central Florida and 1:5 in south Florida (FL Dept. of Comm. Affairs 1988).

Freshwater forested wetlands exhibited a net gain in area over the course of this study. This was in contrast to long term trends which have continually declined since the 1950s. Frayer and Hefner (1991) reported a net loss of 184,000 acres (74,500 ha) of forested wetland from the 1970s to the 1980s. This study estimated a net gain of 22,500 acres (9,100 ha) because of the maturation of shrub wetlands that became forested wetlands. Net gains in forested wetland area did not result from restoration of former wetland or creation of new wetland from uplands. The net gain of forested wetland from uplands was 46 acres (19 ha) over the 11 years and statistically was not significant (Figure 30). Forested wetland gains resulted from the conversion of almost 300,000 acres (118,500 ha) of shrub wetland to wet forest. Most of these lands were observed in production of wood products for lumber, pulp, chip and paper products.

Timber production has been a major land use activity in Florida's forested wetlands (Ewel 1990, Hart and Newman 1995). The amount of forested wetland in a cyclical pattern of growth, cutting and regrowth increased substantially over the past two decades. From the 1970s to 1980s, approximately 234,000 acres (94,700 ha) of wetland trees and shrub habitats alternated between more mature forested wetland stands and wet shrubs once the trees were cut. The amount or wetland area included in the wetland shrub, to forest, to shrub cycle had more than doubled to 500,000 acres (202,400 ha) by 1996.

Large blocks of wetland area changed classification from forested to other wetland types (primarily shrubs) as seen in Figure 31. The long term effects of changes in forested wetland community structure and composition on wildlife populations and other environmental aspects was unclear. Some researchers have reported that silvicultural activities changed the character of the surrounding landscape, and possibly changed the hydroperiod, water depth, water quality and ultimately the fish and wildlife value (Hart and Newman 1995). Others have indicated that cutting and replacement of Florida's old forests with single species that were commercially more desirable seriously damaged the wildlife value of forests (FL Dept. Env. Protection 1996a).

In recent years, silvicultural best management practices have given more emphasis to protecting and maintaining certain wildlife values during forestry activities (FL Dept. of Ag. and Consumer Services 1993). During this study, forestry practices did not result in a loss of wetland area. Forested and shrub wetland areas retained their wetland characteristics and a small gain in wetland area resulted from what had formerly been upland managed forest.

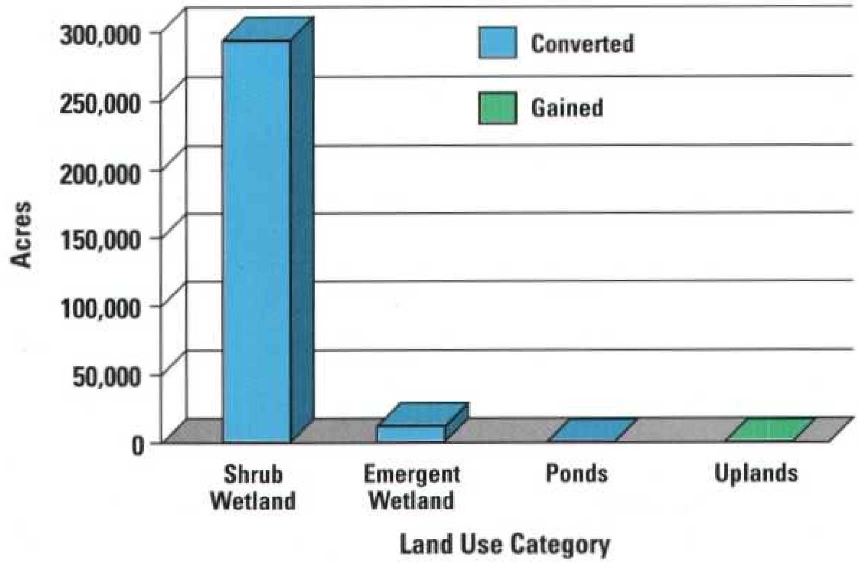


Figure 30. Forest wetlands gained or converted from various cover-types, 1985 to 1996.

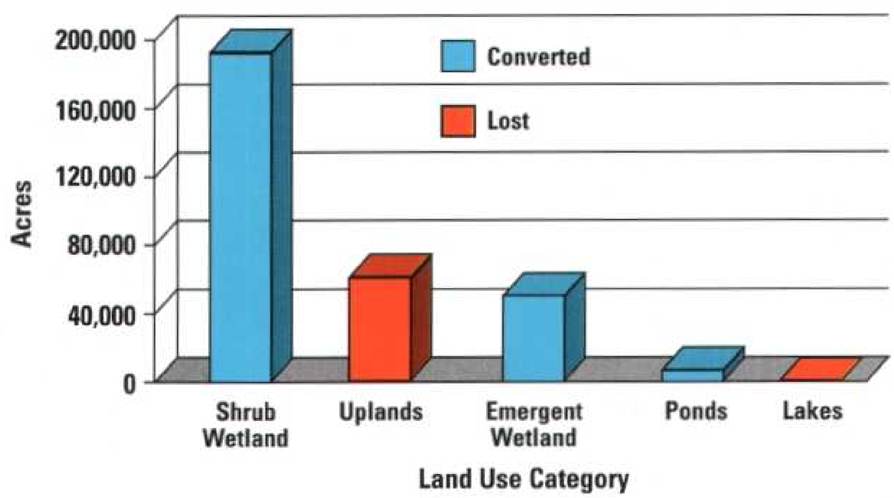


Figure 31. Forested wetlands lost or converted to various cover-types, 1985 to 1996.

Forested wetland losses to various upland land use categories indicated that these wetlands remained vulnerable to urban and rural development. Construction activities in urban and urbanizing rural settings accounted for 79 percent of forested wetland losses to upland (Figure 32). Development activities in rural areas accounted for over 26,400 acres (10,700 ha) of forested wetland loss. This occurred throughout Florida, and included building development on the urban fringe, bridge and road construction, industrial development, construction of recreational facilities and expansion of other infrastructure as a result of rapid growth. An estimated 11,500 acres (4650 ha) of forested wetland area was lost within urbanized cities and towns. Although Frayer and Hefner (1991) did not use a "rural development" upland category to describe wetland losses, their findings indicated that urban development accounted for over 39,000 acres (15,830 ha) of forested wetland loss during the previous decade.

Agriculture was attributed with the loss of an estimated 6,700 acres (2,700 ha) during the 11 year period. This was a 20-percent reduction in the rate of forested wetland loss attributed to agriculture between the 1970s and 1980s (Frayer and Hefner 1991).

Other miscellaneous upland land uses were attributed with 7 percent of the forested wetland loss to uplands during the study.

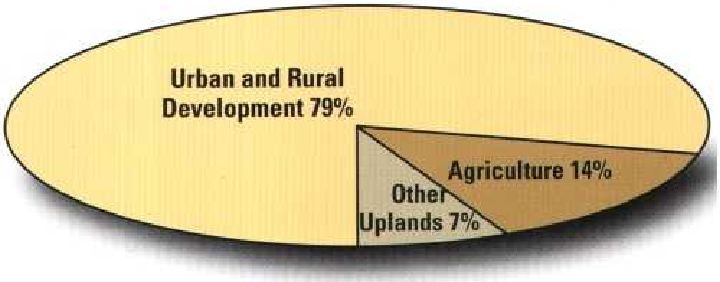


Figure 32. Loss of forested wetlands to uplands, 1985 to 1996.

Freshwater Shrub Wetlands

Shrub wetlands included areas dominated by woody vegetation less than 20 feet tall (6 m) (Figure 33). In Florida's shrub swamps, titi (*Cyrilla racemiFla. ora*), black titi (*Cliftonia monophylla*), swamp honeysuckle (*Rhododendron viscosum*), swamp haw (*Viburnum nudum*), willow (*Salix spp.*) and swamp bay (*Persea palustris*) were common species. Many shrub wetlands had been invaded by Brazillian pepper (*Shinus terebinthifolius*) or *Melaleuca quinquenervia*.

Cowardin *et al.* (1979) did not distinguish between true wetland shrub communities and wetlands dominated by tree species less than 20 feet tall (6 m). Consequently, all small, wet trees were classified as shrub wetlands. This included "dwarf" or "scrub" cypress wetlands (Ewel 1990) that were common in south Florida especially in the Big Cypress National Preserve.

There were an estimated 1,791,100 acres (725,140 ha) of wetland classified as shrubs in 1996. This represented a gain of an estimated 146,400 acres (59,300 ha) or almost 9 percent between 1985 and 1996. Trends in wetland shrubs were strongly influenced by the interrelationship between wetland shrub acreage and wetland forests. Also, there was also a large amount of emergent wetland (306,000 acres or 123,900 ha) converted to shrub wetland during this study.

The increased amount of shrub wetland may have been the result of drier conditions. Several authors (Mitsch and Ewel 1979, Ewel 1990) have discussed the importance of hydroperiod and fire frequency to species composition and productivity in Florida wetlands. Wilson and Loomis (1967) and Mitsch and Gosselink (1993) presented the concepts of classical hydrarch succession where shallow water lakes or wetlands tended to move toward drier sites and eventually became terrestrial habitat. Changes in hydrologic conditions did influence these trends however; there has been little information on

Figure 33. Example of freshwater shrub wetland, Corkscrew Swamp, Florida, 1994.

the long term dynamics of species composition or life form transition that have resulted from drier conditions over regional landscapes.

Of the freshwater shrub wetlands converted to upland, 54 percent or 21,100 acres (8,550 ha) were drained for urban and rural development purposes. Another 11,600 acres (4,700 ha) were lost to agriculture and 6,500 acres (2,630 ha) were lost to other miscellaneous uplands (Figure 34). There were gains to the wetland shrub category from upland forested plantations during this period.

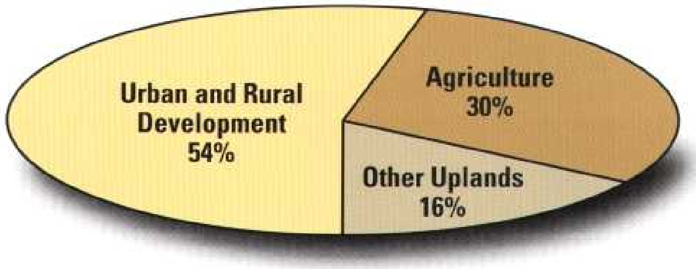


Figure 34. Loss of freshwater shrub wetlands to uplands, 1985 to 1996.

Freshwater Emergent Wetlands

Emergent wetlands generally contained shallow water and were dominated by herbaceous plants (Figure 35). They included areas known as marsh, swale, slough, wet prairie, wet savanna, reed swamps and glades. Relatively frequent fires in combination with fluctuating water levels have maintained the integrity of many of Florida's emergent wetlands (Kushlan 1990).

Emergent wetlands supported abundant wildlife that included aquatic invertebrates, fishes, amphibians, reptiles and mammals. Most notable among the wildlife supported by these wetlands were the wading birds. There were 16 species of wading birds in Florida with representatives from three families: the herons (Ardeidae), the storks (Ciconiidae), and the ibises and spoonbills (Threskiornithidae) (Collopy and Jelks 1989). Freshwater wetlands provided feeding habitats that were important to the survival of these wading bird species. During the wet season (June through November) many emergent wetlands were flooded with shallow water that maximized prey production for birds (Collopy and Jelks 1989).

Other values provided by emergent wetlands benefitted people. Aesthetics have played an important role in defining natural areas throughout Florida's landscape. The "River of Grass" formed by the Everglades, Homosassa Springs, Cypress Gardens, Silver Springs and Myakka River State Park were all examples. Emergent wetlands also provided environmental quality values. They were important components of the hydrologic cycle, retained flood waters and served as depositories for nutrients.

In 1996, there were an estimated 2,636,900 acres (1,067,600 ha) of freshwater emergent wetland in Florida. Emergent wetlands declined by an estimated 9 percent between 1985 and 1996. This was the largest decrease of any wetland category sampled, and these losses overshadowed the area gained in forested, shrub wetlands and freshwater ponds.

Figure 35. Example of a freshwater emergent wetland in central Florida, 1996.

Frayer and Hefner (1991) estimated the loss of freshwater emergent wetlands to have been 110,000 acres (44,500 ha) between the mid 1970s and 1980s. Results from this study indicated the loss rate more than doubled, an estimated 260,200 acres (105,340 ha).

The conversion of freshwater emergent wetland to shrub wetland involved 286,900 acres (116,150 ha). Historically there have always been small conversions between wetland types (i.e. shrub to emergent and emergent to shrub) based on duration and intensity of flooding or frequency of wildfires (Figure 36). Changes of the magnitude that occurred in Florida between 1985 and 1996 were indicative of prolonged periods of drought that allowed woody plants to become established in emergent wetlands, or the invasion of shrubs such as Brazilian pepper or *Melaleuca*.

Agriculture was responsible for some of the emergent wetland loss to upland land uses. An estimated 98,400 acres (39,800 ha) were lost to upland agriculture. Numerous wetlands were also restored or created on land previously classified as agricultural uplands. An estimated 60,100 acres (2,430 ha) of agricultural upland were converted to emergent wetlands and offset some of the losses. Wetland restoration, creation, land retirement or set aside programs were responsible for many of these changes in land use. A net loss of 38,300 acres (15,500 ha) was attributed to agricultural land use. That accounted for 63 percent of the losses to upland (Figure 37).

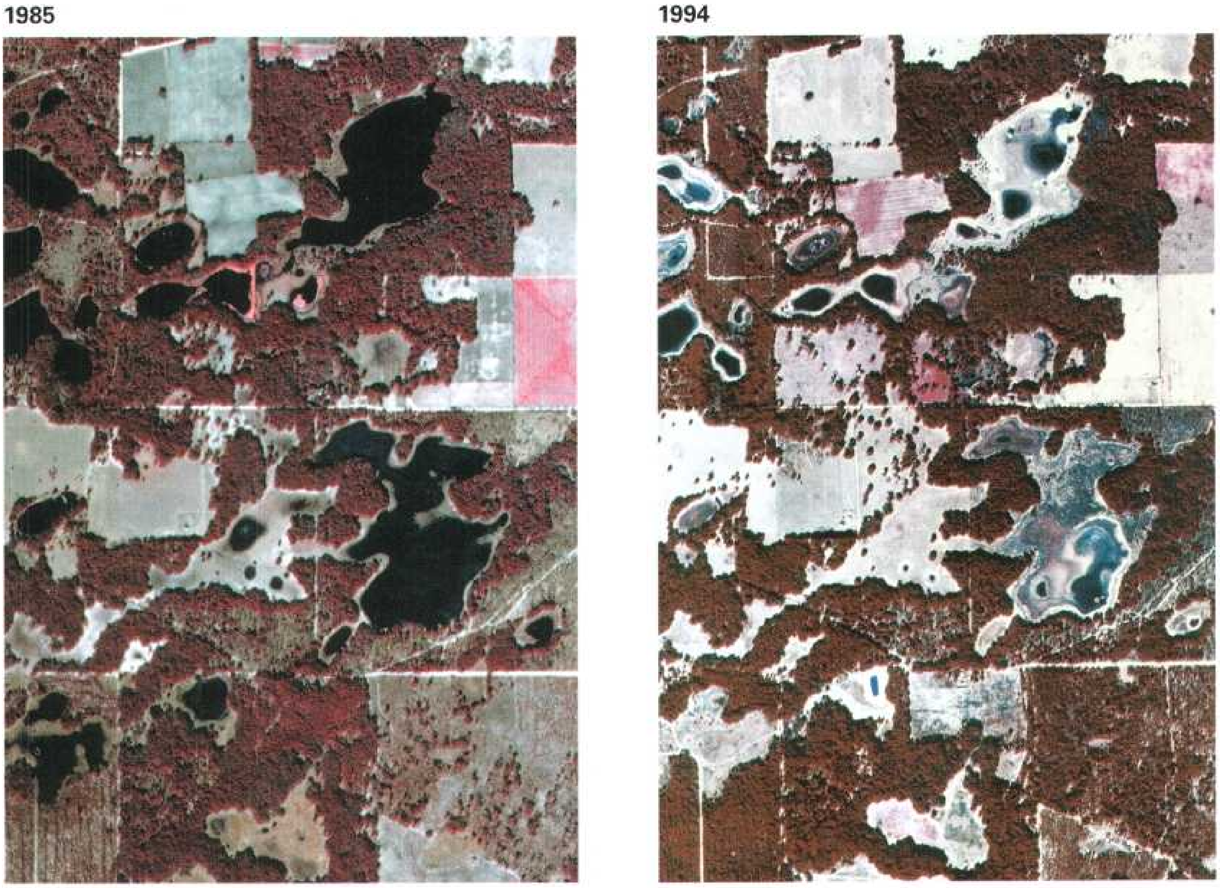


Figure 36. 1985 and 1994 color infrared aerial photographs of wetlands and small lakes, Hatchbend, Florida. (Photos courtesy of FL DEP.)

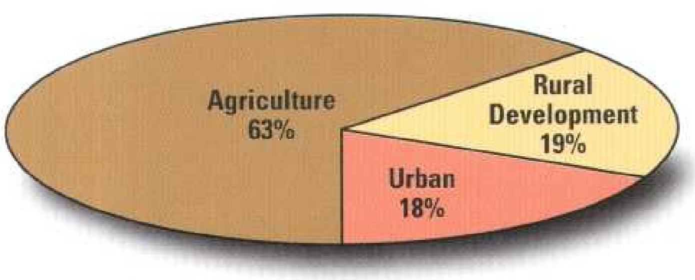


Figure 37. Loss of freshwater emergent wetlands to uplands, 1985 to 1996.

Figure 38. A constructed freshwater pond in a residential neighborhood, Brandenton, Florida, 1996.

Under the definitions of upland land uses used by the Fish and Wildlife Service to conduct this study, agriculture was a broadly applied term that included many agricultural products not limited to commodity crops or traditional row crop agriculture. For example in 1997, Florida led the Nation in the production of 18 major agriculture commodities including sugarcane, oranges, grapefruit, fresh tomatoes, bell peppers, ferns, sweet corn, snap beans, fresh cucumbers, tangerines, temple oranges, fresh squash, radishes, gladioli, tangelos, eggplant, and house plants (FL Dept. of Ag. and Consumer Services 1998). Florida also produced watermelons, endive, mushrooms, peanuts, tobacco, limes, other citrus, potatoes, blueberries, strawberries, lettuce, carrots, cabbage, and ornamental plants and trees for homes, offices and gardens. Agriculture as a land use category in this study also included buildings, field roads and infrastructure directly associated with agricultural operations. Many of the products listed above were not covered under the "Swampbuster" provisions of the Farm Bill and wetlands were subject to drainage without penalty. Citrus production in Florida had expanded the number of acres in production from 1985–86 to 1995–96 by about 266,000 acres (107,700 ha) (FL Dept. of Ag. and Consumer Services 1998). Some of that expansion resulted in drained wetlands.

Urban and rural development were attributed with 18 and 19 percent of the freshwater emergent losses to uplands, respectively. "Other" upland land uses and upland forested plantations were responsible for net gains back to emergent wetland. Each category showed the creation or restoration of about 4,900 acres (2,000 ha).

Freshwater Ponds

Freshwater ponds (Figure 38) continued to increase throughout the State. Between 1985 and 1996 pond area increased by 39,200 acres (15,900 ha). This was almost a 20 percent increase over the previous decade and continued a long term upward trend (Figure 39).

This study included freshwater ponds that were functionally and qualitatively different, and there were many different kinds of ponds found throughout Florida. Some were natural, others manmade.

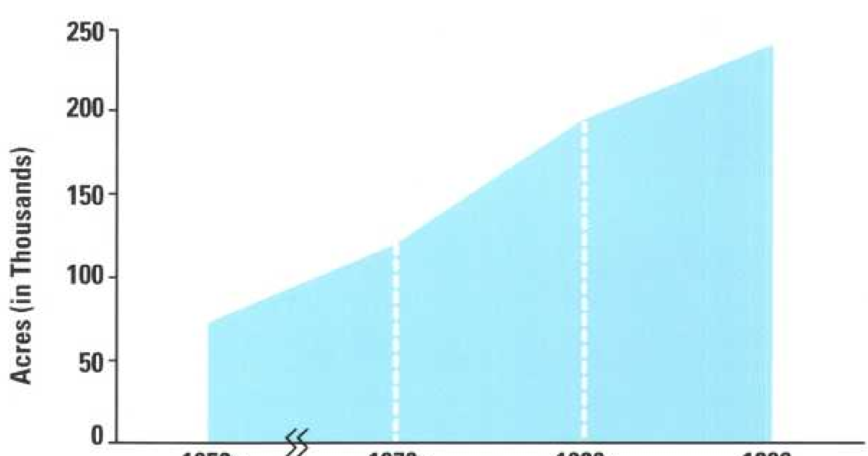


Figure 39. Long term trends of freshwater pond area in Florida.

Open water ponds were created as water retention basins in urban areas, water traps on golf courses (Figure 40), ornamental landscape features for housing or office developments or as a result of rock mining operations. All of these met the wetland definition of Cowardin *et al.* (1979). Very few ponds for catfish farming have been created in Florida (U.S. Dept. of Ag. National Agricultural Statistics Service 2001).

Freshwater ponds exhibited net increases from all of the upland categories with the exception of rural development. About 23,700 acres (9,600 ha) of freshwater ponds were created on agricultural lands between 1985 and 1996.

Upland agriculture was the largest contributor to the freshwater ponds category (Figure 41). Rural development activities were responsible for an estimated 2,000-acre (800 ha) loss in ponds. This was due to the reclamation of open water bodies that had been created during phosphate mining operations.

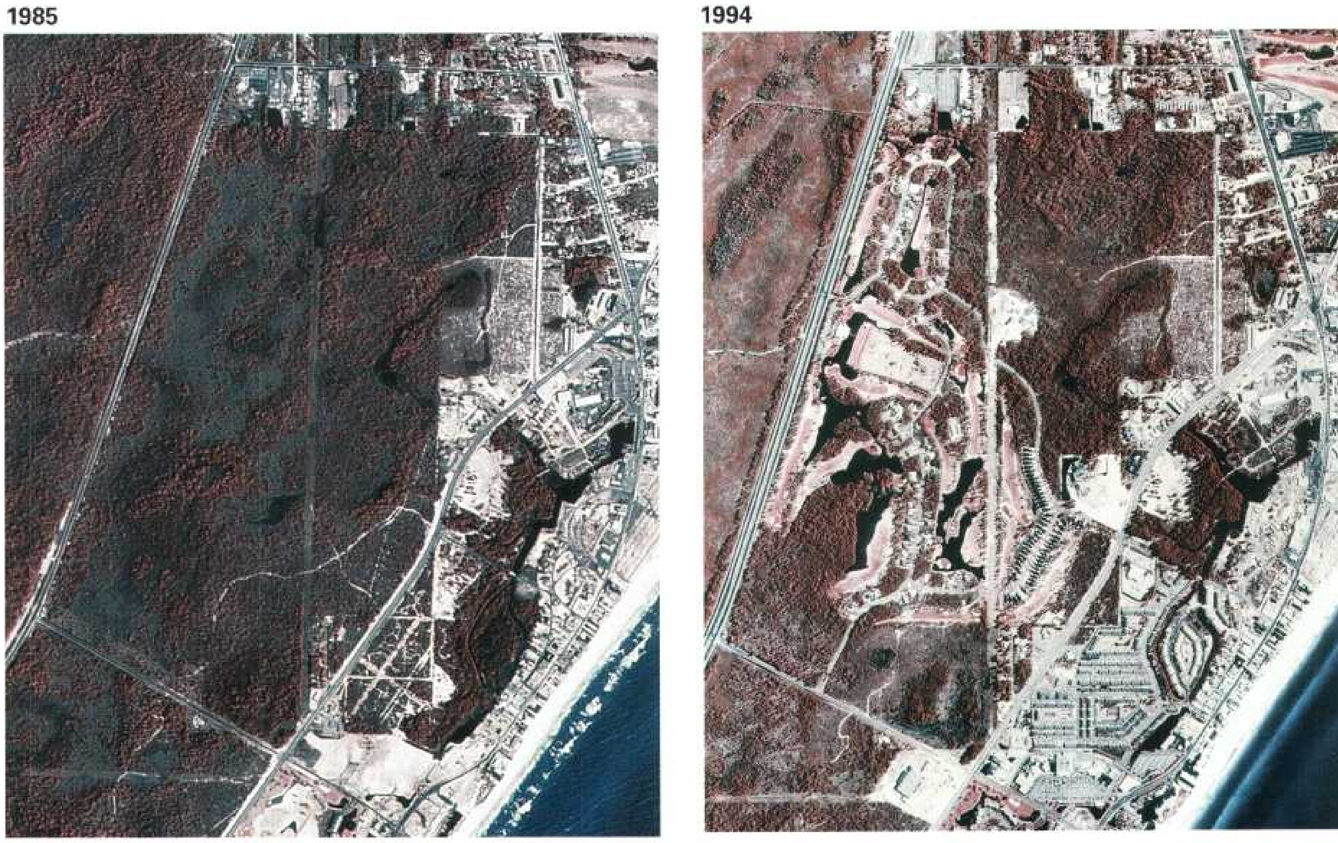


Figure 40. 1985 and 1994 color infrared aerial photographs near Panama City, Florida. (Photos courtesy of FL DEP.)

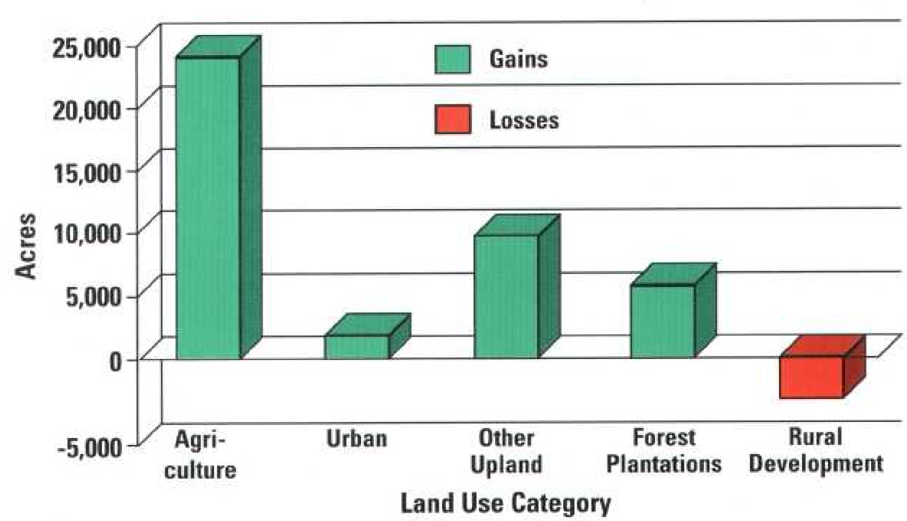


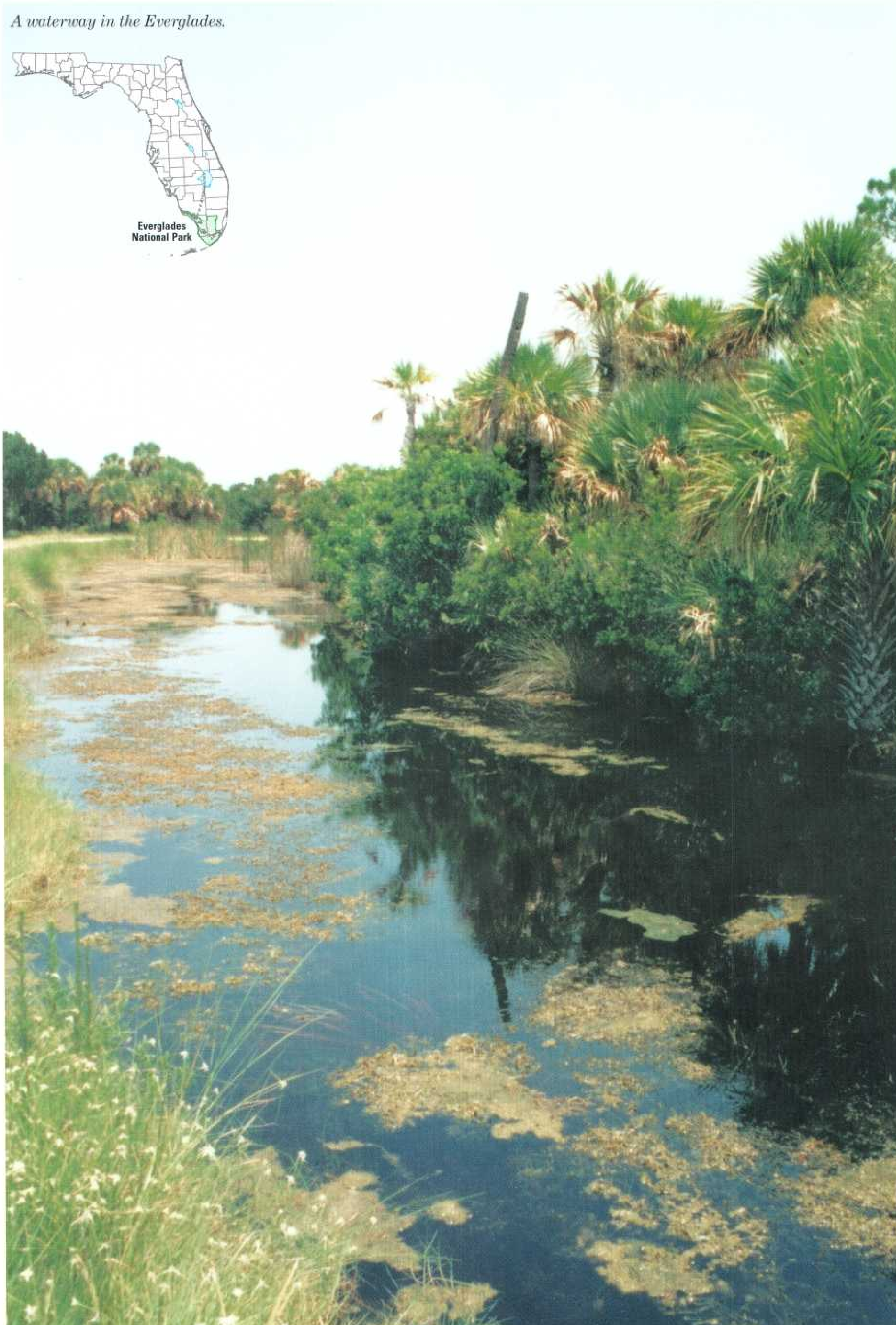
Figure 41. Acres of new ponds created from uplands in Florida, 1985 to 1996.

Wetland Restoration, Protection and Conservation Efforts

There has been considerable emphasis in the last decade on wetland restoration or rehabilitation activities. Many worthwhile projects have been completed by Federal, State, local and private organizations and citizens (Figure 42). In Florida, the term restoration has been used to describe various management practices such as beach clean-up, removal of exotic plants from existing wetlands or the enhancement of condition. The term "restoration" has also been used to describe the return of land area to a former condition or function. Some projects designed to restore hydrologic function or remove exotic species from wetlands have not increased the area of the wetland base. Thus, while successful restoration projects have been very beneficial, the amount of wetland area has not changed. Direct comparisons of wetland restoration estimates from this study with other studies using different definitions of restoration cannot be made.

Gains in wetlands from upland land uses were tabulated as part of this study. Emergent wetland and ponds predominated the wetland from upland restorations. There were an estimated 127,940 acres (51,800 ha) of restoration or creation from uplands in Florida. Approximately 67 percent of the wetland restoration or creation took place on agricultural lands. Agricultural programs that promote wetland restoration, pond creation and land retirement were responsible for these gains. Wetland restoration or creation was dominated by open water pond creation in urban areas and accounted for a small percentage of the wetland area restored or created between 1985 and 1996. Rural development and managed forest plantations accounted for 6 percent each of the wetland area restored or created. "Other" upland land use restored or created 18 percent of the wetland area (Figure 43).

Figure 42. A wetland creation/restoration site in southwestern Florida, 1999.



A waterway in the Everglades.

EVERGLADES RESTORATION PROJECT

Extending more than half the length of the Florida peninsula, the watershed of Florida's Everglades once covered more than 10,800 square miles (27,970 sq. km). This large wetland complex was interconnected by rivers, lakes open ponds, marshes, tree islands, wooded hammocks, bays and coastal mangrove swamps. Surface water traveled slowly from Lake Kissimmee 200 miles (320 km) southwest to reach Florida Bay and the Gulf of Mexico.

During the 1900s, more than half of the wetlands that made up this vast ecosystem were destroyed or degraded, many having been drained or filled for agriculture or residential housing (U.S. Fish and Wildlife Service 1996). Canals and levees were constructed to drain, retain or alter the hydrology of the wetlands of south Florida. As a result of these alterations, most of the peripheral wet prairie, cypress forests and all of the custard apple (*Annona Glabra*) forest that were associated with the historic Everglades have been lost (Davis *et al.* 1994).

Habitat restoration. (Robert Owens)

By 1990, competition for water in south Florida was intense. There were competing demands to support rapidly growing population centers, agriculture and meet the water resource demands of State and Federal parks, reserves, sanctuaries and preserves (McPherson and Halley 1996). The remaining Everglades comprised about 2,300 square miles (5,960 sq. km), three fifths of which was impounded and managed as water conservation areas (Lord 1993). The wetlands of the Everglades had been drastically reduced in size and some suffered from mercury contamination. Others suffered water quality problems, water supply and diversion controversies, declining wildlife populations, increasing pressure from ecotourism, urban and agricultural expansion, and an influx of exotic plant species (Dahl and Allord 1996).

During the early 1990s, five Federal Departments, the Environmental Protection Agency, in partnership with the tribes, State and local agencies, reached a consensus that the Everglades should be restored. The South Florida Ecosystem Restoration Initiative was developed

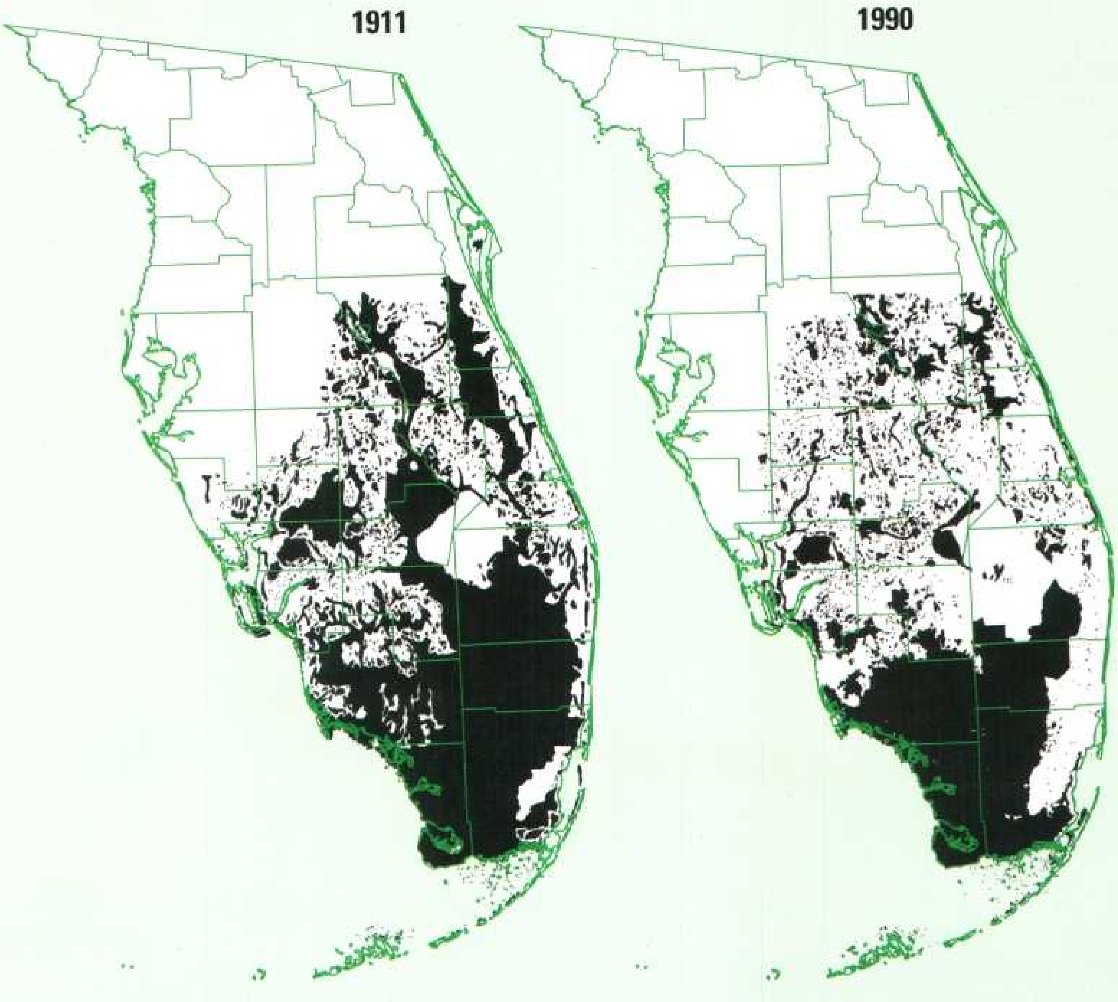
Native pond apple and spatterdock. (Photo courtesy of the South Florida Water Management District.)

Fish and Wildlife Service firefighters monitor a prescribed burn. (John and Karen Hollingsworth) to restore and maintain, to the extent possible, the elements of the south Florida ecosystem to resemble the natural functions of a healthy, balanced and functioning freshwater, estuarine and marine environment (U.S. Fish and Wildlife Service 1996).

Restoring the Everglades remains an enormous challenge that involves returning essential functions to a large and diverse ecosystem. It constitutes the largest wetland restoration effort ever undertaken, and is estimated to cost billions of dollars and take up to 30 years to complete (Eggleston *et al.* 2000). The ability to manage the hydrology of the Kissimmee River, Lake Okeechobee, the Everglades and associated waters, while providing for the needs of urban, rural and agricultural users will determine the future of natural resources of south Florida.

Research on the Everglades System. (Photo courtesy of Everglades National Park.)

Wetlands of the Everglades. (Photo courtesty of Everglades National Park.



The extent of the greater Everglades system in South Florida, 1911 and 1990.

As human development pressures have continued in Florida, there have been increased demands placed on all natural resources. Land needs for wildlife habitat, recreation, green space and surface water protection have been increasingly threatened. In response, Florida has identified acquisition of environmentally sensitive lands as one of its most important strategies for environmental protection (FL Dept. Environmental Protection 1996a). The Conservation and Recreation Lands Program, Save Our Rivers, Save Our Coasts, Land Acquisition Trust Fund Programs and the Preservation 2000 program represented commitments on the part of the State and the Water Management Districts to acquire environmentally important lands. There were almost 7 million acres (2,834,000 ha) of land that had been acquired between State and Federal agencies in Florida (FL Dept. Environmental Protection 1996a). Many of these lands included important wetland habitats. As shown in Figure 44, these lands have been acquired in key coastal wetland areas, the Everglades and the south Florida ecosystem, key watersheds or rivers and other strategic locations for the protection of endangered species or rare habitat types.

Wetland creation and wildlife habitat restoration on lands overlook historic Pelican Island National Wildlife Refuge in 2002. (George Gentry)

Land acquisition has been only one part of the conservation strategy. Many wetlands in Florida have other special designations to help ensure recognition of value or protection. Some of these designations have included the following: National Estuarine Research Reserves, National Marine Sanctuaries, National Estuary Program, Florida Aquatic Preserves, International Biosphere Reserve, World Heritage Site, and Wetland of International Importance (Ramsar Sites).

Florida had also identified "Strategic Habitat Conservation Areas." These lands (about 4.8 million acres or 1,943,300 ha), were subject to loss and degradation because of development pressure and represented some of Florida's most "at risk" resources (FL Dept. Environmental Protection 1996a).

Other important factors that were part of Florida's wetland conservation efforts included Federal, State and local legislation, ordinances and initiatives. Darst *et al.* (1996) has provided a comprehensive discussion of the many government agencies involved in wetland conservation efforts in Florida. The application and enforcement of wetland protection measures, elimination of some incentives for wetland drainage, public education and outreach, private land initiatives, coastal monitoring and protection programs, and wetland restoration and creation actions also contributed to wetland conservation over the past decade. Private organizations have also had an important role in wetland conservation and protection in Florida. Many private-interest groups have kept the public informed on wetland issues, organized citizen networks and lobbied for wetland protection measures (Darst *et al.* 1996).

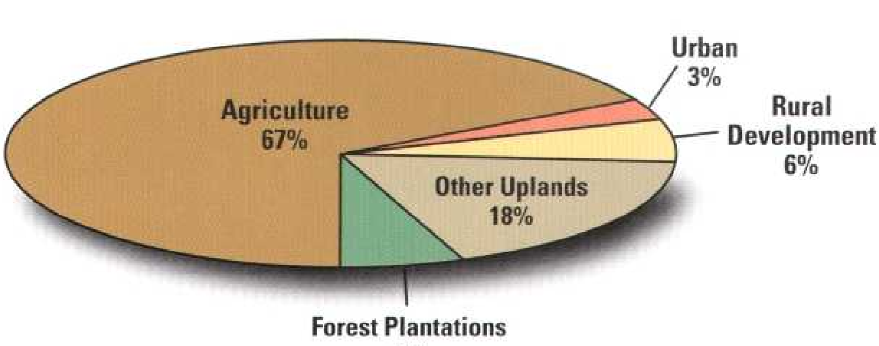


Figure 43. Percentage of wetland area restored or created (ponds and emergent wetlands) from various upland land uses in Florida, 1985 to 1996.

Protected wetlands provide recreation for people and habitat for native plants and animals. Birdwatchers (above) enjoy a sunny day of spotting birds at Ding Darling National Wildlife Refuge. (George Gentry) An alligator surfaces to rest on a log at the Corkscrew Sanctuary in Collier County (right).

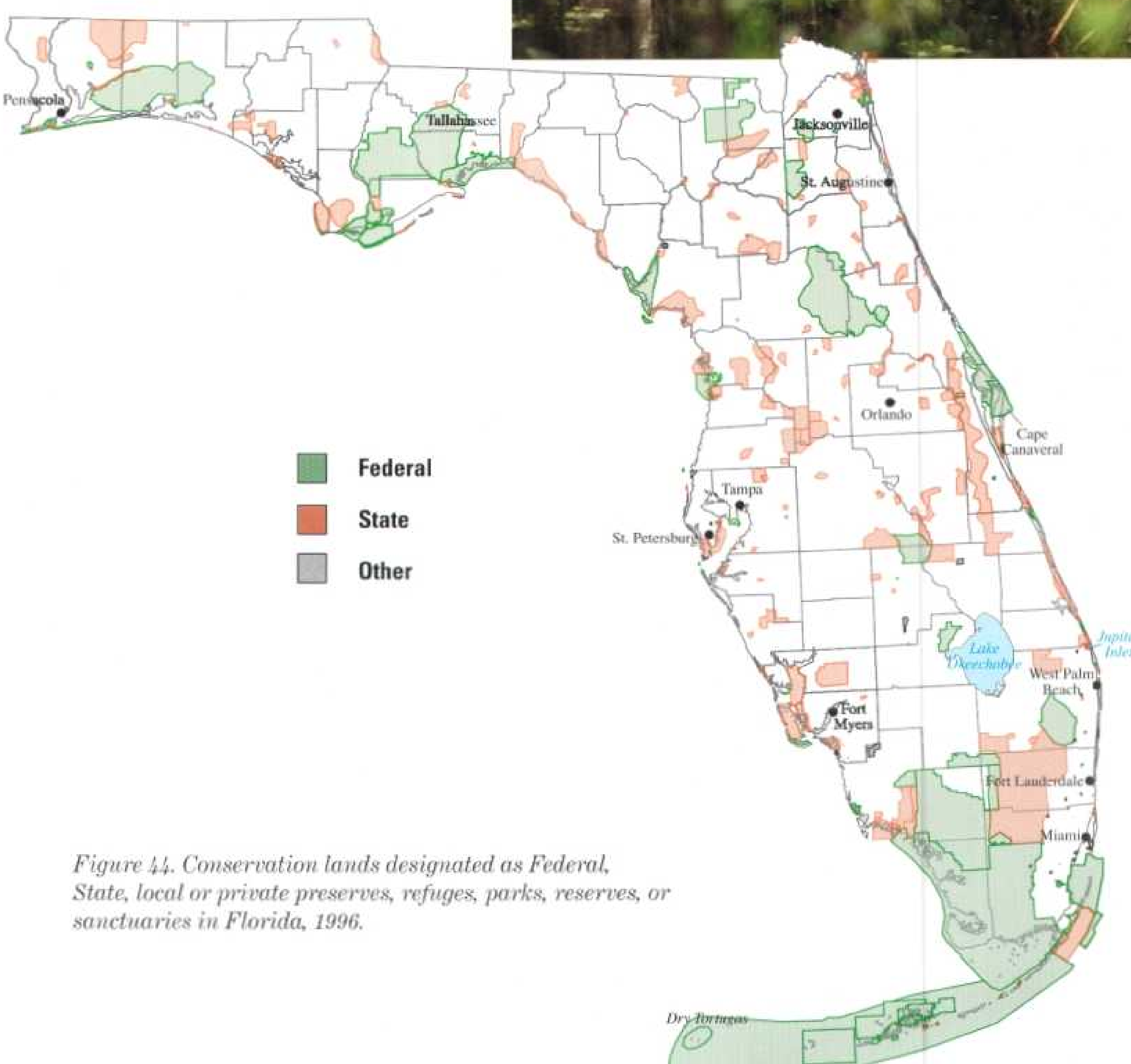


Figure 44. Conservation lands designated as Federal, State, local or private preserves, refuges, parks, reserves, or sanctuaries in Florida, 1996.

Summary

Wetlands have been an important part of Florida's landscape as they have provided many values to wildlife and people. The U.S. Fish and Wildlife Service has developed and maintained a program to assess changes in the Nation's wetland acreage. The statistical design used in the National trend study also produced reliable wetland area estimates for Florida. Six-hundred-and-thirty-six sample plots were analyzed using digital orthophoto quarter quadrangles to identify wetlands, deepwater habitats and uplands. Changes in areal extent or type of wetland observed in the sample plots between 1985 and 1996 were recorded. Field verification was accomplished for 138 plots or 22 percent of the sample. During April 1999, cooperative interagency field evaluations were conducted to test the definitions used by the Service on the wetland status and trends plots to attribute wetland losses or gains. The study produced estimates of total wetland area and changes for Florida that included all lands and waters of the State regardless of land ownership.

As of 1996, Florida had 11.4 million acres (4.6 million ha) of wetlands. Of this, 10 percent were estuarine and 90 percent were freshwater wetlands. Between 1985 and 1996 the average annual net loss of wetlands in Florida was 5,000 acres (2,030 ha). This rate of loss was an 81-percent reduction from the annual rate reported for the previous decade by the Service. Urban and rural development accounted for an estimated 72 percent of the loss. Agriculture was attributed with the remaining 28 percent of the losses. Small gains in wetland were attributed to upland silviculture, the "other" uplands category as well as an increase from deepwater. Although Florida had not reached "no-net-loss" of wetlands, there had been dramatic progress made in slowing the rate of loss.

Less than one percent of the wetland losses that occurred between 1985 and 1996 were intertidal wetlands, as marine and estuarine wetlands declined by an estimated 500 acres (200 ha) over the 11-year period. These losses were attributed to construction activities along the coast, and coastal erosion. Most of Florida's shoreline had been protected either by regulation or through public ownership. These mechanisms in combination with continued awareness and educational efforts were responsible for reducing intertidal wetland losses between 1986 and 1997.

There were an estimated 10,234,800 acres (4,143,600 ha) of freshwater wetlands. Between 1985 and 1996, freshwater forested and shrub wetlands and freshwater ponds increased in area. These gains were offset by large losses to freshwater emergent wetlands. Florida's freshwater wetlands declined by an estimated 52,000 acres (21,100 ha) or 0.5 percent between 1985 and 1996. This was an average annual net loss of 4,740 acres (1,920 ha) for the period. The average annual rate of freshwater wetland loss declined 82 percent since the 1970s to the 1980s era.

There were an estimated 127,940 acres (51,800 ha) of wetlands restored or created from uplands in Florida. Approximately 67 percent took place on agricultural lands. Agricultural programs that promote wetland restoration, pond creation and land retirement were responsible for these gains.

Of the net wetland losses to upland land use, the urban and rural

Rookery Bay National Estuarine Research Reserve.

development categories were attributed with 72 percent of the losses. Agriculture was attributed with 28 percent of the losses. Net gains came from silviculture and the "other" upland categories. There was no net loss attributed to silvicultural practices. There were gains to the wetland shrub category and freshwater emergents from upland silviculture. There was also a net gain in wetland from the "Other" upland land use category.

The wetland loss rate in Florida has been reduced substantially since the last half of the 20th century. The State and the Federal Government had purchased substantial amounts of land for conservation and recreational purposes. Parks, preserves and management areas protect exemplary remnants of most of Florida's natural ecosystems (Myers and Ewel 1990). Restoration efforts have been underway to try and rehabilitate some of Florida's watersheds and wetlands. In the future, Florida faces difficult challenges to try and balance economic growth, rapid population immigration and growth with limited natural resources, land and carrying capacity. Wetlands were a pervasive feature of the landscape, and will remain an important benchmark to the ecological and economic sustainability of Florida and the Nation.

Corkscrew Sanctuary.

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Right: Mangrove thicket of coastal south Florida.

Appendix A.

Definitions of Habitat Categories Used in This Status and Trends Study

Wetlands[1]

In general terms, wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. The single feature that most wetlands share is soil or substrate that is at least periodically saturated with or covered by water. The water creates severe physiological problems for all plants and animals except those that are adapted for life in water or in saturated soil.

Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes,[2] (2) the substrate is predominantly undrained hydric soil, [3] and (3) the substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year.

The term wetland includes a variety of areas that fall into one of five categories: (1) areas with hydrophytes and hydric soils, such as those commonly known as marshes, swamps, and bogs; (2) areas without hydrophytes but with hydric soils—for example, flats where drastic fluctuation in water level, wave action, turbidity, or high concentration of salts may prevent the growth of hydrophytes; (3) areas with hydrophytes but non-hydric soils, such as margins of impoundments or excavations where hydrophytes have become established but hydric soils have not yet developed; (4) areas without soils but with hydrophytes such as the seaweed-covered portions of rocky shores; and (5) wetlands without soil and without hydrophytes, such as gravel beaches or rocky shores without vegetation.

Marine System

The Marine System consists of the open ocean overlying the continental shelf and its associated high energy coastline. Marine habitats are exposed to the waves and currents of the open ocean. Salinities exceed 30 parts per thousand, with little or no dilution except outside the mouths of estuaries. Shallow coastal indentations or bays without appreciable freshwater inflow and coasts with exposed rocky islands that provide the mainland with little or no shelter from wind and waves, are also considered part of the Marine System because they generally support typical marine biota.

Estuarine System

The Estuarine System consists of deepwater tidal habitats and adjacent tidal wetland that are usually semienclosed by land but have open, partly obstructed, or sporadic access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater runoff from the land. The salinity may be periodically increased above that of the open ocean by evaporation. Along some low energy coastlines there is appreciable dilution of sea water. Offshore areas with typical estuarine plants and animals, such as red mangroves (*Rhizophora mangle*) and eastern oysters (*Crassostrea virginica*), are also included in the Estuarine System.

[1]Adapted from Cowardin *et al.* 1979.

[2]The U.S. Fish and Wildlife Service has published the list of plant species that occur in wetlands of the United States (Reed 1988).

[3]U.S. Department of Agriculture has developed the list of hydric soils for the United States (U.S. Department of Agriculture 1991).

Marine and Estuarine Subsystems

Subtidal The substrate is continuously submerged by marine or estuarine waters.

Intertidal The substrate is exposed and flooded by tides. Intertidal includes the splash zone of coastal waters.

Palustrine System

The Palustrine (freshwater) System includes all non-tidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, farmed wetlands, and all such wetlands that occur in tidal areas where salinity due to ocean derived salts is below 0.5 parts per thousand. It also includes wetlands lacking such vegetation, but with all of the following four characteristics: (1) area less than 20 acres (8 ha); (2) active wave formed or bedrock shoreline features are lacking; (3) water depth in the deepest part of basin less than 6.6 feet (2 meters) at low water; and (4) salinity due to ocean derived salts less than 0.5 parts per thousand.

Classes

Unconsolidated Bottom Unconsolidated Bottom includes all wetlands with at least 25 percent cover of particles smaller than stones, and a vegetative cover less than 30 percent. Examples of unconsolidated substrates are: sand, mud, organic material, cobble-gravel.

Aquatic Bed Aquatic Beds are dominated by plants that grow principally on or below the surface of the water for most of the growing season in most years. Examples include seagrass beds[4], pondweeds (*Potamogeton spp.*), wild celery (*Vallisneria americana*), waterweed (*Elodea spp.*), and duckweed (*Lemna spp.*).

Unconsolidated Shore Unconsolidated Shore includes all wetland habitats having two characteristics: (1) unconsolidated substrates with less than 75 percent areal cover of stones, boulders or bedrock and; (2) less than 30 percent areal cover of vegetation other than pioneering plants.

Emergent Wetland Emergent Wetlands are characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants.

Shrub Wetland Shrub Wetlands include areas dominated by woody vegetation less than 20 feet (6 meters) tall. The species include true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions.

Forested Wetland Forested Wetlands are characterized by woody vegetation that is 20 feet (6 meters) tall or taller.

Palustrine Farmed Farmed Wetlands are wetlands that meet the Cowardin *et al.* definition where the soil surface has been mechanically or physically altered for production of crops, but where hydrophytes will become re-established if farming is discontinued.

[4]Although some seagrass beds may be evident on aerial photography, water and climatic conditions often prevent their detection.

Deepwater Habitats

Wetlands and deepwater habitats are defined separately because the term wetland has not included deep permanent water bodies. For the purposes of conducting status and trends studies, riverine and lacustrine are considered deepwater habitats. Elements of marine or estuarine systems can be wetland or deepwater. Palustrine includes only wetland habitats.

Deepwater habitats are permanently flooded land lying below the deepwater boundary of wetlands. Deepwater habitats include environments where surface water is permanent and often deep, so that water, rather than air, is the principal medium within which the dominant organisms live, whether or not they are attached to the substrate. As in wetlands, the dominant plants are hydrophytes; however, the substrates are considered non-soil because the water is too deep to support emergent vegetation (U.S. Department of Agriculture 1975).

Riverine System

The Riverine System includes deepwater habitats contained within a channel, with the exception of habitats with water containing ocean derived salts in excess of 0.5 parts per thousand. A channel is "an open conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of standing water" (Langbein and Iseri 1960).

Lacustrine System

The Lacustrine System includes deepwater habitats with all of the following characteristics: (1) situated in a topographic depression or a dammed river channel; (2) lacking trees, shrubs, persistent emergents, emergent mosses or lichens with greater than 30 percent coverage; (3) total area exceeds 20 acres (8 ha). Similar wetland and deepwater habitats totaling less than 20 acres may also be included in the Lacustrine System if an active, wave-formed or bedrock shoreline feature makes up all or part of the boundary, or if the water depth in the deepest part of the basin exceeds 6.6 feet (2 meters) at low water.

Snorkeler at Fort Jefferson on the Dry Tortugas. (Photo courtesy of Everglades National Park.)

Uplands

Agriculture[5]

Agricultural land may be defined broadly as land used primarily for production of food and fiber. Agricultural activity is evidenced by distinctive geometric field and road patterns on the landscape and the traces produced by livestock or mechanized equipment. Examples of agricultural land use include cropland and pasture; orchards, groves, vineyards, nurseries, cultivated lands, and ornamental horticultural areas including sod farms; confined feeding operations; and other agricultural land including livestock feed lots, farmsteads including houses, support structures (silos) and adjacent yards, barns, poultry sheds, etc.

Urban

Urban land is comprised of areas of intensive use in which much of the land is covered by structures (high building density). Urbanized areas are cities and towns that provide the goods and services needed to survive by modern day standards through a central business district. Services such as banking, medical and legal office buildings, supermarkets, and department stores make up the business center of a city. Commercial strip developments along main transportation routes, shopping centers, contiguous dense residential areas, industrial and commercial complexes, transportation, power and communication facilities, city parks, ball fields and golf courses can also be included in the urban category.

Forested Plantation

Forested plantations include areas of planted and managed forest stands. Planted pines, Christmas tree farms, clear cuts, and other managed forest stands, such as hardwood forestry are included in this category.

Forested plantations can be identified by observing the following remote sensing indicators: 1) trees planted in rows or blocks; 2) forested blocks growing with uniform crown heights; and 3) logging activity and use patterns.

Rural Development

Rural developments occur in sparse rural and suburban settings outside distinct urban cities and towns. They are characterized by non-intensive land use and sparse building density. Typically, a rural development is a cross-roads community that has a corner gas station and a convenience store which are surrounded by sparse residential housing and agriculture. Scattered suburban communities located outside of a major urban center can also be included in this category as well as some industrial and commercial complexes; isolated transportation, power, and communication facilities; strip mines; quarries; and recreational areas such as golf courses, etc. Major highways through rural development areas are included in the rural development category.

Other Land Use

Other Land Use is composed of uplands not characterized by the previous categories. Typically these lands would include native prairie; unmanaged or non-patterned upland forests and scrub lands; and barren land. Lands in transition may also fit into this category. Transitional lands are changing from one land use to another. They generally occur in large acreage blocks of 40 acres (16 ha) or more and are characterized by the lack of any remote sensor information that would enable the interpreter to reliably predict future use. The transitional phase occurs when wetlands are drained, ditched, filled, leveled, or the vegetation has been removed and the area is temporarily bare.

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[5] Adapted from Anderson *et al.* 1976

Appendix B.

This table presents estimates of acreage by classification, and the number of acres that changed classification between 1985 and 1996. The rows identify the 1985 classification; the columns identify the classification and acreage for 1996. The number under the acreage estimate for each entry is the percent coefficient of variation for that estimate.

1985 Classification and Acreage		1996 Classification: Saltwater							Freshwater			
		Marine Subtidal	Marine Intertidal	Estuarine Subtidal	Estuarine Intertidal Aquatic Bed	Estuarine Intertidal Emergent	Estuarine Intertidal Shrub	Estuarine Intertidal Unconsolidated Shore	Palustrine Aquatic Bed	Palustrine Emergent	Palustrine Forested	Palustrine Shrub
Saltwater	Marine Subtidal	179568 42	774 72	24722 96	0 —	0 —	0 —	1393 77	0 —	0 —	0 —	0 —
	Marine Intertidal	515 60	25577 39	142 96	0 —	0 —	31 96	1262 66	0 —	0 —	0 —	0 —
	Estuarine Subtidal	0 —	0 —	2497709 5	0 —	1626 60	429 46	4649 24	0 —	0 —	0 —	0 —
	Estuarine Intertidal Aquatic Bed	0 —	0 —	0 —	0 —	0 —	0 —	0 —	0 —	0 —	0 —	0 —
	Estuarine Intertidal Emergent	0 —	0 —	290 60	0 —	306194 17	9612 41	76 51	0 —	0 —	0 —	0 —
	Estuarine Intertidal Shrub	0 —	0 —	90 82	0 —	5396 59	602541 14	156 80	0 —	0 —	0 —	0 —
	Estuarine Intertidal Unconsolidated Shore	0 —	0 —	6561 41	0 —	954 67	3647 47	171990 22	0 —	0 —	0 —	0 —
Freshwater	Palustrine Aquatic Bed	0 —	0 —	0 —	0 —	0 —	0 —	0 —	16251 19	4163 27	14 98	1160 37
	Palustrine Emergent	0 —	0 —	0 —	0 —	0 —	48 96	0 —	1032 43	2412070 11	9968 80	306204 19
	Palustrine Forested	0 —	0 —	0 —	0 —	0 —	0 —	0 —	7 98	41654 22	5261776 5	187284 26
	Palustrine Shrub	0 —	0 —	114 96	0 —	0 —	0 .	0 —	24 96	19310 18	292778 31	1285364 9
	Palustrine Unconsolidated Bottom	0 —	0 —	22 98	0 —	0 —	0 —	0 —	1985 34	9990 17	655 98	770 29
	Palustrine Unconsolidated Shore	0 —	0 —	0 —	0 —	0 —	0 —	0 —	0 —	1214 48	0 —	232 53
	Palustrine Farmed	0 —	0 —	0 —	0 —	0 —	0 —	0 —	0 —	14 98	0 —	14 98
Deepwater	Lacustrine	0 —	0 —	0 —	0 —	0 —	0 —	0 —	922 64	66401 21	0 —	5116 50
	Riverine	0 —	0 —	0 —	0 —	0 —	0 —	0 —	0 —	51 70	0 —	7 98
Upland	Agriculture	0 —	0 —	76 96	0 —	0 —	0 —	0 —	7 98	60134 39	94 98	1465 44
	Urban	0 —	0 —	111 68	0 —	0 —	0 —	221 78	18 81	343 87	0 —	14 98
	Forested Plantations	0 —	0 —	0 —	0 —	0 —	0 —	0 —	0 —	4937 56	628 60	1325 62
	Rural Development	0 —	0 —	0 —	0 —	0 —	0 —	41 96	0 —	2490 46	0 —	404 91
	Other	0 —	111 96	280 79	0 —	228 58	0 —	131 94	7 98	14139 34	332 98	1764 54
	Acreage Totals, 1996	180083 42	26462 38	2530116 5	0 —	314398 17	616308 14	179919 21	20253 18	2636911 10	5599246 5	1791124 9

and Acreage

			Deepwater		Upland						
Palustrine Unconsolidated Bottom	Palustrine Unconsolidated Shore	Palustrine Farmed	Lacustrine	Riverine	Agriculture	Urban	Forested Plantations	Rural Development	Other	Acreage Totals, 1985	
0 —	0 —	0 —	0 —	0 —	0 —	0 —	0 —	0 —	0 —	206458 38	**Marine Subtidal**
0 —	0 —	0 —	0 —	0 —	0 —	0 —	0 —	0 —	0 —	27527 38	**Marine Intertidal**
43 98	0 .	0 —	0 —	0 —	14 96	38 70	0 —	208 86	0 —	2504716 5	**Estuarine Subtidal**
0 —	0 —	0 —	0 —	0 —	0 —	0 —	0 —	0 —	0 —	0 —	**Estuarine Intertidal Aquatic Bed**
17 96	0 —	0 —	0 —	0 —	7 96	10 96	0 —	0 —	0 —	316207 17	**Estuarine Intertidal Emergent**
118 56	0 —	0 —	0 —	0 —	442 70	743 59	0 —	892 58	107 96	610485 14	**Estuarine Intertidal Shrub**
0 —	0 —	0 —	0 —	0 —	0 —	176 77	0 —	0 —	73 69	183400 21	**Estuarine Intertidal Unconsolidated Shore**
1723 25	58 98	0 —	79 98	58 98	313 45	129 54	0 —	433 60	72 98	24452 17	**Palustrine Aquatic Bed**
9564 13	2807 42	8149 41	12799 52	1191 62	98438 20	11234 35	125 73	14275 24	9186 41	2807092 10	**Palustrine Emergent**
3213 29	108 98	38 82	492 46	0 —	6789 28	11487 35	582 38	26424 38	3892 49	5543746 5	**Palustrine Forested**
2617 29	58 87	0 —	615 74	253 93	13086 35	10645 45	645 51	10884 46	8268 51	1644682 9	**Palustrine Shrub**
144483 8	606 45	287 61	1541 43	0 —	1590 37	1487 33	202 71	6822 65	237 43	170678 8	**Palustrine Unconsolidated Bottom**
794 48	3468 24	0 —	79 82	0 —	61 69	135 54	0 —	314 52	0 —	6296 20	**Palustrine Unconsolidated Shore**
23 98	0 —	1997 47	0 —	0 —	452 39	0 —	0 —	0 —	0 —	2500 38	**Palustrine Farmed**
2860 44	0 —	0 —	1611909 17	0 —	0 —	5157 75	0 —	3615 54	101 69	1696171 17	**Lacustrine**
0 —	0 —	0 —	0 —	135142 33	0 —	0 —	0 —	87 98	0 —	135287 33	**Riverine**
25288 21	353 57	946 40	34103 49	0 —							**Agriculture**
3258 28	0 —	0 —	579 65	0 —							**Urban**
2768 47	1205 98	79 98	4250 95	0 —							**Forested Plantations**
5233 27	290 71	0 —	8076 48	14 98							**Rural Development**
9350 21	52 70	0 —	1801 47	14 98							**Other**
211351 8	9005 29	11496 31	1676435 17	136672 32							**Acreage Totals, 1996**

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February 2005